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MANAGEMENT, GROUP CONFLICT AND THE SCIENCES

by

THE EARL OF HALSBURY

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Consider the building of a hut or a canoe in Polynesia. It is in some sense a spontaneous act, subject of course to ritual precedent and ritual consequent. The decision to act gets taken, as it were, without anyone taking it. It is also a communal act. In the selection of site, materials, tools and so on, each member of the group has his part to play.

Any spontaneous communal act of this kind calls forth a spontaneous system of communication having a hierarchical component. This appears to be the cultural origin of what later evolves into the problem of management.

THE SOCIOLOGICAL APPROACH

We may thus suppose that the raw material on which cultural evolution works consists of a physical and a psychological situation—an industry in canoes and huts on the one hand, and a social and psychological hierarchy tied to it on the other. Originally correlated, they tend to evolve independently; for once a material situation is recognized, there is always a 'logical next step' which appears to be called for; while psychological forces acquire a reality and a life of their own once they have been brought into existence.

Management is thus concerned with creating a state of affairs which would not occur spontaneously in its absence, and which is regarded as desirable according to some material criterion. If material criteria were met spontaneously, management would not be necessary. We desire something to happen. If something else happens, or if nothing happens, a management situation arises.

One is often struck by the failure of treatises on management to make sufficient allowance for this aspect of the subject. Management is an act which occurs in opposition to some form of resistance, and to treat it as a mere problem in communications is quite inadequate. No mere verbal exposition of what a man does not want to do will make him want to do it.

The fact that someone else wants it will not make him want it either. In some way the individual has to identify his wishes and hopes with those of others with whose wishes and hopes his own were originally in conflict.

This is roughly what happens in the relations linking senior and junior management in any large organization. Individual managers at every level including the highest can, on occasion, be extremely refractory, obstructive and generally unco-operative. A system of group loyalties and *esprit de corps* ties them together, however, and each individual is subject to psychological pressures tending to make him identify himself with the management group as a whole. 'Loyalty to the firm' thus binds them together, and what is in the interest of the whole will ultimately seem to be in each individual's own interest, and will thus produce co-operation. This is the point at which text-book expositions arrive before they drop the subject, apparently unaware that great numbers of the human race are psychologically immune to any such approach. As a corrective, let us return to the standpoint of social anthropology.

Human nature may be over-endowed with cultural possibilities; but no one culture can realize more than a fraction of these possibilities. We therefore see a mosaic of culture patterns scattered over the world, each different from, and usually incomprehensible to, the other, the members of any one pattern tending to regard their village totem-pole as the centre of the universe, their tribal customs as part of the natural order of things, and the ways of strangers as potentially dangerous. Above all, there is no brotherhood of man. Brothers are made, not born. The taboo upon the stranger is ubiquitous, deep seated and rigid until exorcised by ritual initiation into the group.

It is not necessary to confine our attention to Polynesia, for we can see these same deep forces at work in the social activities of the most advanced groups. Consider, for instance, how one joins an exclusive club. The candidate must be sponsored; he must have a proposer and seconder; his name must be written in the candidates' book; members add their names under his in support; when this support has reached a critical level it is considered by the elders (the committee of the club) and the candidate may be elected. If it is a learned society, further rituals and solemnities may have to be performed before he becomes a member of the brotherhood.

If we seek to understand the forces that hold men together in groups or sunder them in conflict, we seem to find a good model in the short-range saturation forces of chemistry.

The gravitational field of the sun stretches out to infinity; it attracts every piece of matter contained in the field without regard to the number of competitors for its attraction. In contrast, a hydrogen atom exercises its attraction for other hydrogen atoms over a short distance only. The force is 'cut off' at a few diameters' distance; moreover, when two hydrogen atoms have become attracted to one another so as to form a hydrogen molecule, their

power to attract other hydrogen atoms disappears and is replaced by a force of repulsion.

A society made of individuals subject to forces of this kind would accordingly form molecular groupings depending upon the way in which geography and occupation presented opportunities for ties of brotherhood or antagonism between the members. By analogy with the kinetic theory of gases, one would suppose that the collision-frequency, or frequency of approach, exercised an important effect upon the chances of group formation in this way. The frequency of approach, being a function of density, would accordingly be associated with local condensations determined by geography, so that the occupational group (the factory) and the residential group (the village) would crystallize out of the melt.

Within any one culture pattern a mosaic of variant sub-patterns can therefore be seen, each with its characteristic ideology. The tyranny of words forces us to oversimplify the situation. We talk of 'the industrialist' and 'the trade-unionist' because grammar and syntax do not permit us to talk of them at all unless we talk of them in this way. Grammar and syntax however evolved long before social anthropology needed to express its findings within their framework. When we say 'the industrialist' or 'the trade-unionist' we imply a homogeneity that does not exist. We need some North American Indian language which would enable us to treat as single nouns such complexes as the following:

'Church-going-factory-manager-with-strong-sense-of-public-service';

'Free-trade-golf-playing-managing-director-believing-keep-out-of-my-way';

'Union-chairman-christian-naming-employers-confederation-operating-ancient-agreement-never-broken';

'Vicariously-bitter-shop-steward-with-chip-on-shoulder'.

There *are* such languages, but as English is not one of them, we must make do with paraphrases as we go along.

GROUP ATTITUDES

The above analogy of a group ideology forming like a crystal out of a melt is fertile if it is remembered that the 'phase-change' of the chemist is limited to changes between a finite number of discontinuous states. The compound H_2O can exist as ice, water or steam. It cannot exist in any intermediate form. Under exceptional conditions two phases can co-exist; ice and water at the melting point, water and steam at the boiling point. The whole temperature range, however, is split up into three compartments. Below the freezing point there is only ice. Between freezing and boiling points only water, and above the boiling point only steam.

Over a wide range of conditions a group ideology may similarly preserve

its character inviolate. A phase change, if it occurs, will tend to be discontinuous, and involve a transformation to a highly contrasting ideology. Marxist theorists have always been acutely aware of these transformations, and their lively treatment of them was once a source of attraction to students of sociology and history. It is unfortunate that their subject was historically wedded to a nomenclature (dialectical materialism) which seems to have prevented its evolution and confined its outlook within very narrow limits.

In terms of these reflections upon the crystallization and maintenance of group ideologies, consider the following case histories:

A. The factory is well run and contented. The management are on good terms with the shop stewards, and the shop stewards are on good terms with both union headquarters and local officials. The management is competent, but not so outstanding as to attract notice in a crowd. It makes mistakes from time to time, but puts them right before any serious damage is done. The unions know this, and managerial mistakes are treated with forbearance. This happy state of affairs has gone on from time immemorial. No one planned it so, and no one appears to be doing anything in particular to keep it so. Above all, there is no formula. One cannot point to any practice which could account for the pleasant atmosphere summed up in the sentence: 'We never have trouble here.'

B. The factory was well run and contented under manager X, but is going downhill under manager Y, who doesn't seem able to hit it off with the shop stewards. Mr. X was, by common consent, an outstanding person, and his passing was deplored by all. In due course Y is replaced by Z, and the factory atmosphere reverts to its old tone. Everyone agrees that 'there'll never be another like old X', but there is no general agreement as to why Y was a failure. He is considered to have been good at his work and personally pleasant, but just didn't get on somehow. Z is no better as an organizer and a bit more of a martinet, but it is agreed that with Z 'you always know where you are'.

C. The factory is a grave-yard of previously stainless managerial reputation. The atmosphere is like that of a disturbed beehive. No one seems able to do anything with it. The management cannot get along with the shop stewards, local officials or union headquarters; and union headquarters cannot get along with the shop stewards or the management. Management negotiates agreements with the union which are not kept, and the union is embarrassed by unofficial strikes which always seem to seek a good end by a bad means. The general manager has been transferred and replaced over and over again, but it has never made any difference: 'There's always been trouble here.'

The reader familiar with industry should have no difficulty in selecting examples from his experience for comparison with the above three patterns. In the first instance a sanguine frame of mind having emerged spontaneously in the factory group, no particular effort is required to maintain it. The management does not need to consist of outstanding individuals, since the sort of tricky situations which call for outstanding qualities do not arise. In the third group a spontaneously unhappy pattern has emerged and no mere managerial manipulation will ever put it right. The situation is basically neurotic; it resembles the culture pattern of a certain island in Melanesia, where everyone suspects everyone else of trying to kill him by black magic, and where a man's daily life is controlled by the need to take suitable counter-measures. The second group is an intermediate case. The group ideology has formed around an individual and will continue to need an individual to maintain it. Its well-being will therefore depend upon the qualities of the individual.

Treatises on managerial techniques which avoid reference to these basic situations merely skim the surface of the subject. If social anthropology and industrial psychology are to be the nuclei of some future intellectual discipline which will transform and adjust human relations in accordance with human needs, then our present indifference to the realities of 'intractable situations' must give way to an active interest in what ought to be the heart of the subject.

Tractable situations are, after all, tractable. If we know what to do and have the will to do it, then an undesirable state of affairs will remedy itself in due course. A few pioneers will take the lead, and the rest of the community, given time for imitation, will follow suit. In this way, factory welfare and managerial interest in worker's recreational and social life have spread throughout the industrial community without too much effort. In this way, too, joint consultation between unions and employers has spread until it is now a characteristic feature of modern industrial life. These are the mechanical contrivances of management. What is of paramount interest is why they are frequently ineffective. Why is one local ideology apparently unable or unwilling to copy what is manifestly successful elsewhere?

COMPENSATION MECHANISMS

The situation resembles not so much that of a man who has an incurable disease as that of one who has a remediable ailment for which he declines to utilize the known remedy.

A well known phenomenon involving individuals seems to have its parallel in society, namely 'secondary gain'. Consider a man paralysed in the legs as a result of an accident, and who is awarded a pension. His ability to walk

and run, to go to places of amusement or to play football or cricket for recreation, has disappeared. This is his loss. He enjoys however a secondary gain—he no longer needs to earn his living or make an effort to feed himself. Suppose now that a discovery in medical science enables him to be cured. Will he take advantage of it? If he has had sufficient time to accustom himself to the secondary gain, the answer to this question is all too often: 'No! Why abandon a pension and comfort in a lowly station and go working merely to chase a football about?' In dealing with neurotic patients the psycho-analyst is well aware that the first and greatest obstacle to be overcome is a reluctance to be cured, if by being cured is meant being interfered with. Excuses of all kinds, logical and illogical, are synthesized in a stream, each justifying inaction. In fact, the patient does not want to be disturbed and comes to terms with life on an unsatisfactory basis for the sake of a secondary gain.

Many of our local ideologies are neurotic in this sense. Consider the following spectrum of case histories ranging from the rational to the neurotic.

D. Two generations ago a certain union and the employers of its members negotiated an agreement for joint consultancy designed to avoid strikes arising from disputes. The agreement made by the grandfathers of those now bound by it stands unamended. It has never been breached by either side and is now a sort of mascot. Both parties derive considerable satisfaction from this, and neither would jeopardize the present very pleasant state of affairs. It enables each to be agreeably superior to third parties. The president of the union can say to a colleague elsewhere: 'If our expenditure on strike pay was a tenth of yours, I would get the sack. We haven't had one in living memory and my members wouldn't stand for it', adding under his breath apropos of his colleague's union: 'Pack of amateurs.' The chairman of the employers' confederation can say to a fellow industrialist from another industry: 'Can't understand how you chaps ever pay a dividend. My shareholders wouldn't stand for your style of bickering with the unions. Why don't you get around the table like we do?' The answer, as often as not, is that they do, but nothing comes of it. In such a case joint consultancy is a mere contrivance imposed upon an ideological conflict but incapable of solving it. It has nothing in common with joint consultancy springing from ideological harmony, and the mechanics of the contrivance are quite unable to transform conflict into co-operation.

In marked contrast with the foregoing are the following attitudes:

E. An American trade-unionist is speaking: 'Automation? It's as good a stick as any to beat the employer with. I don't mean beat him up, just beat money out of him. Not all his money, naturally. One mustn't kill the goose that lays

the golden eggs. I've got to get my members just as much this year as will enable me to get as much and a little more next year.'

F. His counterpart, an American employer, rejoins: 'How do I get along with the unions? I just treat them as an act of God and hire a team of production engineers to beat each pay-rise by the time it's granted.'

It is clear that attitudes E and F above are utterly different from attitude D. There is no sentimental mascot derived from grandfather's generation, no superciliousness with colleagues. The attitudes reflect those of professional buyer and seller anxious to do business and knock off when the clock strikes six. From the standpoint of the social results they are however equivalent. D and E F do not mention co-operation explicitly, but it is present by implication inasmuch as each exploits a healthy recognition that they both live in the same world. If the union were renamed 'The Operatives' Hire and Maintenance Inc.' and run as a competitive business, its ideology would be largely unaffected.

While very different in some respects, the attitudes compared and contrasted above have one obvious feature in common—they are healthy attitudes in the sense that they are subservient to a 'reality principle'. The world is accepted for what it is, things are called by their proper names, and the party with whom discussions are to take place is simply a fellow negotiator on the other side of a conference table.

Let us consider next some more neurotic attitudes.

G. A trade-unionist speaks: 'The time for words is past. We must pass to deeds. If you want to understand the meaning of what we shall do, read the story of St. George and the Dragon like I do, and then you will understand us. There can be no going back and no compromise. It's victory or death now.' (Of course, they compromised and no one got killed).

H. An employer speaks: 'Sorry as I am to say it, there'll never be peace in industry till there's a queue outside these gates.' (An exasperated colleague was heard to mutter at this point: 'Do you think they'd stay outside the gates?')

Let us look at the unreal components in the foregoing attitudes. By 'unreal' I mean components based upon fantasies rather than the actualities of the situation. The speaker in G clearly identified himself with St. George going forth to battle. As it was part of his fantasy life, it would have been useless to tell him that he was *not* St. George going forth to battle. He would merely have agreed—and pursued the fantasy as before. It was all shadow boxing.

As to the speaker in H, he also was living in a dreamland—an authoritarian

dreamland where his discipline would be unquestioned and where the malcontents who had been plaguing him would be happy to ask his forgiveness. He knew with one half of his mind that the innumerable queues outside factory gates in the inter-war years were not associated with peace in industry, and that no one in those days begged to be forgiven for plaguing him or anyone else. The other half of his mind, the half that included his fantasy, was however in control.

The analysis of such individuals is not difficult. The problem, however, is not how they get that way, but why they get elected to responsible positions. In one union, the speaker G would be regarded as an irresponsible lunatic, in another he is regarded as a valuable and trusted official. The same applies, *mutatis mutandis,* to speaker H in the case of employers' confederations.

We must suppose that representation by neurotic individuals in some way reflects a group neurosis. If so, what 'secondary gains' prevent the group from copying more advantageous attitudes? What law of conservation of pattern inhibits a phase-change to a more sanguine mood?

VICARIOUS BITTERNESS AND GROUP AGGRESSION

It is a well established fact that, as children, most individuals experience violent and frightening attacks of hostility to their environment. Whatever the genesis of these attacks may be, there seems to be general agreement among the different schools of analytical psychology that their indulgence is feared and felt to be dangerous. They are accordingly repressed, and any subsequent manifestation of them in the form of a leakage from the unconscious arouses strong feelings of guilt and anxiety. If the original repression was not very successful, leakage recurs, and a way out of the tension caused by the associated feelings of guilt and anxiety is frequently found by displacing the aggression on to something which does not arouse a sense of guilt. An imaginary opponent is very effective for this purpose, especially if condemnation is possible on the rational as well as the emotional level.

Dickens' Mr. Dick, preoccupied with King Charles' head, is a loveable literary prototype of a man with his aggression displaced in this way, a prototype of all those who would sooner brood over wrongs done to others in the past than take a realistic view of their own position in the present. The behaviour of the English to the Irish under Cromwell, or of the Irish to the English in the Rebellion of 1798, the Peterloo massacre, the Tolpuddle martyrs, the American Civil War, the Paris Commune of 1871—all these have power to arouse passions of an intensity quite inappropriate to contemporary society. A young generation of South Africans is growing up who feel far more deeply and bitterly about the South African War than did their grandparents or great grandparents who actually fought in it. As colonialism

declines, we can observe local hostility to it, rising to a hysteria which is out of all proportion to any feelings it might have aroused when it was at its height.

The scapegoat, it will be remembered, was loaded with the sins of a whole people. It may be that aggression displaced on to a common scapegoat is felt to be a safer form of indulgence than aggression expressed in privacy. If so, the existence of a genuine grievance, however trivial, could, by focusing communal attention on itself, initiate an upsurge of neurotic group hostility directed against an adversary endowed with imaginary but hateable characteristics.

Aggression thus indulged tends to overflow and become increasingly unreal. Revolutionary extremists, whether of the Left or the Right, seem to conform to type with fair regularity. In stage one they set out to put right a grievance. In stage two they exaggerate their adversary's objectionable qualities. In stage three they project these exaggerations on to anyone who fails fully to share their feelings, as if indifference were a threat to the sense of security provided by indulging in shared aggression. In stage four they strike out blindly at a world peopled by monsters of their own imagining and identified with the manifestly harmless individuals who, until recently, were their neighbours.

Revolutionary extremism represents the neurosis in advanced form. Attitudes G and H quoted above represent a mild, early, and often transient attack. One can easily visualize the consequences of bringing people with these attitudes round a conference table. Each will argue, not with a fellow human being on the other side of the table, but with a shadow projected from within his own shadows and endowed with qualities of malicious intelligence entirely belied by the realities. The opponents are probably both nicer and more stupid than neurotic hostility will allow. If this is the case, then clearly it is a waste of time to say to groups conflicting at this level: 'Why don't you get round the conference table?'

INDIVIDUAL EGOTISM AND GROUP LOYALTY

The next attitude chosen for analysis is rational as far as it goes, though not necessarily ethical. It can be illustrated by reference to the ubiquitous need to control inflation based on excessive pay claims. Capitalist society has always contained an inflationary trend. Marx, who lived in one of the rare periods when prices were stable, evidently discounted this trend when prophesying that the dead-weight of old capital would force down the profit rate, upon the maintenance or increase of which the system depended for its driving power. In the deflationary period of the early 1930's it almost seemed as if his prophecies might come true, but the expansionist period under

Roosevelt demonstrated that inflationary writing off of old capital was a positive advantage to society. Inflation favours new capital rather than old, and strengthens debtor rather than creditor. It ensures that re-equipment pays an increasing dividend with the years, and stimulates productivity accordingly. While a steady secular inflation is thus beneficial, galloping inflation, like any other violent change in social structure, is not. To control inflation and prevent it from getting out of hand is therefore a public need of the greatest importance. However, the individual or the sub-group may not see it in this light. Beating inflation can thus be a tricky business. For every inflationary dollar created by one group, all other groups must be impoverished by the same amount. If a dollar per head in one group is born at the rate of one cent per head by the community, the gainer of the dollar may only too easily argue: 'Why not? It means ninety-nine cents net to me, and the others won't notice the loss of a cent.'

This attitude will be resisted by those responsible for a nation's currency control. If their resistance is ineffective, then one of two consequences must follow. They can compensate—by lowering the investment rate to the prejudice of economic growth and expansion; or they can compete—by creating inflationary capital to finance the needs of industry. The first expedient cannot be maintained indefinitely. The second implies that those responsible for the control of inflation have embarked on the very course which it is their responsibility to condemn. Even so, disaster may not be round the corner. If inflation in other countries is taking place at a similar rate, parities will be maintained as the inflationary spiral is ascended, and social adjustment to it may remain a domestic matter.

The need to bring events in other countries into the picture complicates the latter to the point where only a professional economist can understand it. The following attitude is therefore an understandable sequel.

I. 'Don't tell me why I shouldn't have that dollar. I've spent all my life being told why I shouldn't have it. And I never yet heard of an employer who paid me a dollar unless he could afford it.'

For good measure let us give the counterpart attitude:

J. 'I couldn't care less what happens to my estate when I'm dead, since my children won't get it. I'll give them therefore all I have less estate duty in my lifetime, and spend the estate duty myself on having a good time. Wrong? So is tax at 95 per cent of my income.'

The foregoing attitudes are rational enough. Unlike neurotic emotions, rational emotions diminish in intensity with time and space. We all of us draw a line somewhere and say: 'Beyond this lies the future. Let the future take

care of itself.' Or, 'This side of the line is home, and charity begins there.'

Anyone disposed to criticize I and J on ethical grounds will be committed to a dispute on where an arbitrary line should be drawn. In so far as I and J are open to rational criticism, it must be because, in choosing a short-term view, they have actually miscalculated the short-term effects of what they propose to do.

PROFESSIONAL ATTITUDES

Group negotiations are in practice never carried on between groups. They take place between negotiators representing them. These negotiators occupy points on a spectrum stretching from the pure amateur at one end to the pure professional at the other. Their attitudes towards their status as negotiators must be a factor of some importance in determining the way negotiations proceed. They may or may not identify themselves with the group that they represent; they may or may not share its ideology. It seems reasonable to assume that the professional will be less likely than the amateur to concern himself with group ideology, and more likely to represent the group's views dispassionately on a consultant-client basis, just as a lawyer will be concerned with winning his client's case irrespective of sympathy for his client's feelings or aspirations. It also seems reasonable to assume that the professional will be more anxious to calculate precisely what his client can hope to obtain, and then seek to obtain it, than to bargain in the manner characteristic of an Oriental bazaar. In a bazaar the seller demands an outrageous price, and the buyer makes a ridiculous bid; both sides know in advance that these are preliminaries to a compromise which they proceed to achieve by gradual contractions of the margin between them. I have suggested coining the word 'bazaargaining' to describe this procedure. Attitudes to bazaargaining vary widely. Some regard it as a fascinating exercise; others think it a bore. A professional negotiator would presumably treat it as neither, but as a tool to be used or discarded depending on the tactical opportunities it offered in the particular circumstances of a case.

An important feature of the professional's attitude is reluctance to give a point away on behalf of his client without instructions. If the client is a collective, a group, reference back for instructions is clumsy to the point of virtual impossibility, and professional reluctance to give way even on a trivial point may cause negotiations to be long drawn out. The protraction of negotiations in this way may itself contribute to modifying group attitudes.

The foregoing is but a sketch of the attitudes with which management has to cope as a matter of routine. Management considered as a mere problem in communication cannot deal with them. If every node in a communication network consists, not of a simple relay, but of a coding box which transforms

messages received and alters their meaning prior to retransmission, no mere inclusion of extra links in the network will give its output an intelligible harmony. Reference back to the building of a hut or canoe in Polynesia and to attitude D above (related to the two-generations-old agreement between employers and unions) will serve as a reminder that one characteristic of a viable attitude is spontaneity. How can spontaneously good inter-group relations be fostered of set purpose and design? How do we modify our own attitudes? Let us reflect on this first before considering how we modify other people's attitudes.

INTROSPECTIVE FEED-BACK

Feed-back presents many topics for discussion. One of its properties is that it stabilizes a system and renders the performance less sensitive to the load. Introspection has just such a stabilizing effect upon the performance of the mind and appears to be a sort of feed-back. The man who can say of himself: 'I recognize from of old certain symptoms which suggest that I am about to lose my temper', can do all sorts of things to prevent himself doing so. He can take a deep breath; he can pray for patience; he can make an excuse to leave the room to cool off. The man who is not aware of his own symptoms in this way has no such protective feed-back and will go on to the point where his temper is irrevocably lost. The introspective recognition of an attitude as one of several alternatives must go a long way towards weakening its hold.

Words, which so often exercise an evil tyranny over our minds, have in this context some power to heal. We can avoid our neighbours' company, reject their attitudes, condemn their ideologies and disagree with their conclusions. The one thing that we cannot avoid indefinitely is their vocabulary. If new technical terms are coined, such as 'attitude survey', and if they spread into the language, large numbers of people will be led in due course to ask what they mean. If an attitude survey is carried out in one organization, neighbouring concerns will hear of it and want to know what it is all about. If people accustom themselves to such surveys, they will in due course come to think of their own attitudes not as something unique, but as small samples of something more general. All this must have a calming and rationalizing influence. An objective recognition of one's attitude is a prerequisite to its critical examination. From this point of view, consider the tragic conflict of attitudes between the two Great Power blocks in the world today and how it is evolving under the influence of the hydrogen bomb controversy.

There is one proposition on which East and West are in complete agreement: that each is unique. One is uniquely good, and the other uniquely bad. They are divided on only one point—which of them is which? So long

as this attitude persists, there is no hope of reconciliation. The biggest single step forward would consist in recognizing the basic falsity of the one premise on which they can agree—their uniqueness. If each side could be led to see itself as typical rather than unique, and their conflict as a classical 'estrangement syndrome' with its concomitants of anxiety, suspicion and secretiveness, then a major victory for reason over fantasy would have been won.

But for the hydrogen bomb the prognosis would be poor, the syndrome being in an advanced state. The mere existence of the bomb, however, is forcing a revision of attitudes. War is no longer a menace to the defeated only. *Vae Victis* has become meaningless. It is characteristic of an estrangement situation that neither party will make the first concession for fear that it might be regarded as a sign of weakness. The bomb goes part of the way to resolving this situation. An admission that there is no answer to it need no longer be taken as a sign of weakness. Both sides are still close enough to reality to concede that two and two make four, and the unanswerable power of the bomb falls into this category of concession.

In the so-called 'summit' conversations this was apparently agreed. The existence of larger loyalties than local ones was hinted at; the survival of the species was mooted as a possible rival to the survival of any particular system. Notwithstanding subsequent disappointments, it was the first hopeful sign that attitudes could undergo modification, albeit at the eleventh hour. Be it noted that whatever concessions were made must have sprung from introspection. Neither party was apparently influenced by arguments coming from the other.

EXTERNAL INFLUENCES

If we modify our own attitudes by introspection, we can modify other people's attitudes in three ways—by arguing with their content, by creating a climate favourable to the emergence of competitive attitudes, and by forcing introspection upon them.

One can only argue with the content of a rational attitude. As, however, society's more troublesome attitudes are neurotic, argument is not likely to get us very far.

Creating a climate favourable to the emergence of alternative attitudes can be illustrated by reference to the problems associated with the so-called colour bar. For rather obvious climatic reasons, human pigmentation deepens form pole to equator. The climatic optimum for human activity lies in an intermediate zone, which has shifted northward in historical times under the combined influence of a secular change in the climate, soil exhaustion in the early centres of civilization, and an increasing ability to create artificial climates in otherwise sub-optimal zones. This last began by learning to keep

warm in sub-optimal cold climates; its current phase is concerned with mastering the technique of keeping cool in sub-optimal hot climates (air conditioning).

At a critical point in time a world-wide migration of the most technologically advanced peoples took place from the northern temperate belt into the tropical and equatorial belts, and a group of attitudes crystallized around certain associated contrasts which they noticed in the course of their migration: technological contrast, cultural contrast, pigmentary contrast. These contrasts all heightened the taboo on the stranger, and this taboo, instead of centring itself on the technological and cultural contrasts, which would have been its normal and rational manifestation, acquired a neurotic component and centred itself on the pigmentary contrast, thereby permanently sundering peoples whom fate had joined. For technological and cultural contrasts may be transient, but pigmentary contrast must be quasi-permanent. There are plenty of historical precedents for the technological and cultural separation of near neighbours. A culture bar may be regarded as a normal phenomenon. A colour bar appears abnormal and without historical precedent, unless the coincidence of the word for caste and colour in India is evidence of a similar state of affairs in the remote past.

Two attitudes, both somewhat neurotic, now characterize the conflict between extremes. One, out of resentment or anxiety, seeks to abolish every culture bar, together with the colour bar; the other, out of fear, seeks to retain the colour bar in order to preserve any culture bar at all. This is yet another 'estrangement situation'. In a situation of this kind, the less these feelings are indulged, the less intense they become. Provided emotions on either side can be kept below fever-point, they will subside in due course. The problem is how to procure the necessary intermediate state of self-restraint on both sides. In a deadlock of this kind, people seem curiously reluctant to remember that they are mortal and that the race renews itself in a new generation every 20 to 30 years. There is a half-way house between the complete introspection, which can control and modify an attitude, and the state of affairs in which the attitude is completely unchecked. This intermediate condition is represented by the frame of mind of one who can say: 'I see that my attitude is arbitrary and but one of several alternatives, of which it may not be the best; it is nevertheless my attitude.' Having progressed thus far, he could add the rider: 'Maybe my children will be able to see more clearly than I can.' From this it is only one step on to saying: 'I will teach my children that they must solve this problem.'

It has to be remembered that a phase-change in attitudes can take place under the influence of a floating minority. Mild and quite unobjectionable propaganda in schools enjoining on children the solution of a problem their parents have failed to solve may be sufficient to endow them with a desire to solve it. It is not necessary to teach them how; the mere will towards solution

should be sufficient to produce the critical minority shift in 20 years' time.

One can, to some extent, watch an unplanned example of this evolution taking place today in the U.S.A. The desegregation programme for the schools is encountering active local resistance, on the one hand, but making some progress against anxiety in a general way, on the other hand. It is clear that the next generation of adults, themselves educated in desegregated schools, will have an entirely different attitude from that of their parents. This will be a consequence of the desegregation programme, which might have been even better conceived if this kind of evolution had been its objective.

So much for the creation of a climate favourable to the emergence of alternative attitudes. The third method is that of enforced introspection. If an attitude has a neurotic component, it is useless to argue against it. The proponent will always, in his own mind, get the better of the argument. More effective is the question: 'I wonder what makes you say that?' This exercises a powerful irritant action combined with the property of a trigger.

The question implies that the attitude under discussion stems from internal rather than external causes. The more the response relies on the latter, the less it answers the implications of the question, which then eats inward corrodingly until the questioned party is forced to ask himself: 'What *does* make me say that?'

Such enforced introspection occurs whenever a group finds itself under discussion in the press, over the radio, or on television. If the discussion is between scientists—who are manifestly more interested in how controversialists behave than in the content of their controversy, in the course of controversies rather than their origin, in the rates of change of attitudes rather than in their rights or wrongs, in the balance of social facts rather than the merits of social sympathies—then a similar trigger gets pulled. No man likes being viewed objectively through another man's microscope under conditions which destroy his sense of uniqueness. Involuntarily subjected to it he will wriggle and start to argue with himself: 'I am *not* just a typical controversialist with an arbitrary attitude', and sooner or later will come to the horrid sequel: 'Or am I?' Once embarked on the first stage of introspection, he can be left to himself; in the introspective battle enough victors will emerge to exercise a decisive influence at some later time.

Consider, by way of illustration, a culture bar as distinct from a colour bar. It is quite a normal phenomenon, an aspect of the taboo on the stranger. What sort of questions would a sociologist studying this problem ask himself? Religious culture bars will serve as well as any other for this purpose. How, for example, do social contacts between such cultural groups compare on a geographical basis: Christian and Jew in New York, Jew and Muslim in Jerusalem, Muslim and Hindu in New Delhi? How often do members of such groups meet one another? If the statistical collision frequency of the average New Yorker with a fellow New Yorker is x and the collision

frequency between a Christian New Yorker and a Jewish New Yorker is αx, then what is the value of α in New York? What would its corresponding value be in Jerusalem and New Delhi?

Minorities may live below the average cultural level (Puerto Ricans in New York) or above it (Jews in London or Parsees in Bombay). A wealthy minority may exercise an influence out of proportion to its numerical representation in the community, and which is consequently felt to be alien and unpopular. How does the attitude of Christian to Jew in New York compare with that of Hindu to Parsee in Bombay? Do they resemble one another on the basis of inter group-hostility? If not, is it because Christians react differently from Hindus, or because Jews behave differently from Parsees? What maintains a culture bar and gives it durability? If caste originally implied colour in India, what culture bar stabilized it after it had lost its original significance and function in segregating Aryan from Dravidian?

It is difficult for neurotic prejudices to survive long in such an atmosphere of objective inquiry. The more that people can be subjected to such inquiries, the better it will be for the mental health of mankind.

THE IMPACT OF SCIENCE ON SOCIETY

To consider the impact of science on society without including the science of society itself would indeed be like playing Hamlet without the Prince of Denmark.

What is society? It is group within group within group. Each is characterized by a culture pattern, an attitude, an ideology, and there is a constant interaction between these patterns and attitudes. The problem of controlling them is, in its widest sense, the problem of management. The character and scope of the manager change as the hierarchy is ascended. Sometimes the title changes, obscuring the continuity. In America the head of an industrial concern and the head of the government are equally entitled 'President'. In England they are entitled Chairman and Prime Minister. Whatever the title, their task is the same: to manipulate situations controlled by attitudes, refractory attitudes which are not easily changed and yet upon the transformation of which the evolution of society depends.

Technology was once no more than the semi-intuitive power of man over materials, altered here and there and from time to time by an occasional discovery. That power is, under modern conditions, expanding in a planned and controlled fashion, guided by the great corpus of scientific knowledge established by observation, experiment and theoretical generalization.

Society was once no more than men's intuitive groupings in response to the situations and imbroglios in which they found themselves from day to day and to the conflicts of attitudes to which they gave rise. Does man have it in

his power to re-group the members of society and transform their attitudes under the guidance of anything which could be called a 'technology' of society?

Here we must retrace some of Auguste Comte's thinking and undo errors in what was, for its day, a valiant attempt. Comte's sociology, like Aristotle's chemistry, was premature inasmuch as the facts at his disposal were inadequate, the most important having yet to be discovered and established. Aristotle tried to build a philosophy on 4 elements where 92 were needed, and Comte tried to build a sociology out of the history of Western Europe and the influence of the Church. He could not have been expected to know that Western Europe needed to be studied in terms of knowledge to be won in Polynesia.

We can however follow Comte in noting that mathematics is easier than physics, which is easier than chemistry, which is easier than biology, which is easier than psychology, which is easier than sociology. In each succeeding element of this hierarchy the subject matter becomes more refractory, and the theoretical treatment more tenuous. In mathematics we are free to invent. If — 1 has no square root, we invent it. In physics we cannot invent bineutrons or such-like non-existent particles. The subject begins to control what we may do. Chemistry is more difficult to reduce to conceptual precision than physics. Until the first quarter of the century it had to take the 92 known elements and find out how they behaved in combination. Until 1929, it had to work out a satisfactory scheme of relationships between them without any notion of what such relationships might conceivably be. It is astonishing to remember now how the whole structure of modern chemistry was sketched out without a generally accepted theory of what chemical combination meant or of the forces that constituted a chemical bond.

Biology is more difficult still. Now, in the mid-twentieth century, we are winning the first solid knowledge of how the mechanism of reproduction may work through the double spiral of the nucleic acids. Biology has had to do without a single clue to this mysterious phenomenon for more than two hundred years.

With psychology we enter a new order of difficulty; the reaction of chemicals with one another may be more obscure than the reflection of light off mirrors, but at least the chemicals cannot object to our experiments. Human beings, however, can and frequently do object to being observed and experimented upon, and there are rigid limits to what one may do with them. In sociology the observational difficulties increase correspondingly.

It is no wonder then that the order in which valuable knowledge has been won, in which each science has reached a mature phase, has followed that of intrinsic difficulty. Sociology is thus the youngest and most immature of the sciences. It is none the less a science, not by virtue of its achievements or by the nature of its subject matter, but by the spirit in which its

practitioners approach the problems it raises. So long as they are tied to observation, it must of course remain an observational science. But only a very narrow mind would seek to identify science with physical science.

In trying to unify and generalize upon the observations, one would naturally look first for a uniform nomenclature and method of treatment. Preliminary attempts to do this in mathematical terms are not unpromising.

To begin with, the approach has to be modest. We have first to seek for some concept which can lend itself to quantitative treatment, and then see if it can be applied to express simple facts about society of a rather obvious character. If all the obvious facts about society can be expressed in terms of the same concept and the same symbolic nomenclature, then the first stage of inquiry will have been achieved. If it be objected that the symbolism expressed nothing but trivialities, it could be rejoined that establishment of the trivia is necessary to gain confidence in the adequacy of the symbolism. Thereafter the symbolism can be used (as in any branch of applied mathematics) to deal with more complicated situations where purely verbal analysis would lose itself in a labyrinth of description.

Consider, for instance, what we mean by a group. It is in virtue of what that we say that an individual is a member of it? We recognize him as a group member in terms of a criterion of group behaviour. The group is a group because all its members are behaving in a defined way. We know that if we removed a member from the group and placed him in some other group, he would, in due course, start to behave in some other way.

What do we mean by saying that A influences B? A preliminary but narrow answer would be: 'A influences B, means that B copies A's behaviour.' It is clear that if a group of people are all copying one another and doing the same thing, they will all go on doing it indefinitely. The group thus maintains its identity.

We can, however, take the idea a little further. We can use the *difference* in B's behaviour when A is influencing him and when A is not influencing him as a *measure* of A's influence over B in some chosen respect, and accordingly define the coefficient of influence of A over B in terms of this measure. Some quite satisfactory and reasonable models of group structure can thus be arrived at. Coefficients of influence can be regarded as reciprocal and in general of uneven strength. A may dominate B in one respect, and B may dominate A in another. The coefficients of influence exerted by the rest of the group on B may be spread over its members according to some assumed distribution law, and B's capacity to influence other members of the group may be similarly, though not identically, distributed. The frequency and direction of contacts between group members can also be brought into the picture. There result some formidable integro-differential equations, too difficult to solve in general terms, and not worth solving in particular cases, until they have been simplified and reduced to situations where the answer

could in any case be found in words. For example, a continuous distribution of reciprocal influences among the members of a group can be simplified so as to describe a dominant majority and a subservient minority.

It should be clear that this treatment deals with the consequences of people influencing one another, and not with the causes of influence. Influence could be by telepathy, hypnosis or the bayonet for all the difference it would make to the mathematics involved.

Rashevsky's approach deserves mention here.[1] Let us draw from it one particular result to illustrate the sort of argument put forward here. This relates to analysis of the way in which a minority of influential members can initiate a phase change in group attitudes. The example studied by Rashevsky has a bi-stable characteristic similar to that of a flip-flop in electronic circuitry, where the system is stable in either of two states. In the case of the flip-flop, a pulse on the cathode line will switch it over from one state to the other. In the case of the social group studied by Rashevsky, the same switching role is played by an influential minority. After switching, it is the group as a whole, not the minority, which determines the stability of the configuration. This conclusion is unaffected by the character of the influential minority; they could be hypnotists, philosophers, negotiators or gunmen, or a mixture of all these types. Now it may be asked: as we know all this, why put it into mathematics? The answer is two-fold: firstly, it is satisfactory to find that an abstract symbolism leads to results we can confirm by experience; secondly, the treatment of such a simplified case suggests that the quantitative evaluation of more complicated systems would be worth while.

A contributory factor to social discontents is undoubtedly the fact that progress made in solving social problems is slow and discontinuous, whereas people expect it to be rapid and continuous. As a result, people lose patience and make things worse for themselves by behaving irrationally. They would feel less frustrated if they knew what to expect. Thus a more authoritative account of switching phenomena would relieve social tensions by damping exaggerated hopes, while at the same time encouraging a reasonable optimism for a satisfactory long-term issue. When one considers the influence that Engels' scheme of the 'Transformation of quantity into quality' has had on human attitudes, it seems reasonable to suppose that the quantitative treatment of Rashevsky, more scientific and less partisan in spirit, could be no less influential in the long run.

'Why should the devil have all the good tunes?', it has been asked apropos of church music. 'Why should neurotic attitudes have exclusive access to the daily press?', one might echo. Save on the principle of deep calling unto

1. N. Rashevsky, *The Mathematical Theory of Human Relations: an Approach to a Mathematical Biology of Social Phenomena*, Bloomington, Indiana, 1947.

deep, there appears to be no satisfactory answer to this. It is for sociologists to become the influential minority capable of switching our attitudes over from one configuration to another. We have already seen that objective discussion over the radio, for instance, can exert a powerful trigger action on attitudes which are partly neurotic. In Rashevsky's terms, the sociologist's coefficient of influence is high, but his collision frequency with the public is low.

The social sciences are not only the youngest and the cinderellas of the sciences; they also lack their popularizers. The natural sciences have their Jeans's, Eddingtons, Hoyles, Gamows a-plenty. The Ruth-Benedicts and Margaret-Meads of the sociological world are still too few and far between.

As was said of the third estate, what is sociology? It is nothing. It should be everything. Of all the sciences, it should exercise the most powerful impact on society, just as introspection exercises the most powerful influence on our minds.

REHABILITATION—A MILESTONE IN SOCIAL MEDICINE

by

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INTRODUCTION

To lose a limb or the normal use of a limb is a phenomenon as old as the history of mankind. The cause may be congenital malformation, infection by bacteria or viruses, certain forms of poisoning, degenerative diseases, wars, accidents, etc. For many centuries such a disability was generally considered to be the private affair of the individual concerned, even if it were the result of action undertaken in the interest of the community. The best that could be expected was that medicine men, barbers or surgeons would attempt to prevent the invalidating processes from going any further. A certain amount of sympathy and perhaps some financial assistance might also be expected from relatives and friends—particularly if the defect was not too disfiguring. But in primitive communities the disabled were more often than not left exposed to their surroundings in such conditions that—unable to fend for themselves—they must succumb and perish. They were not actually killed off; they were simply unable to survive. And this was the fate not only of the disabled, but in some cases also of children and the aged.

However, with the progress of education among the lower and middle classes in the more enlightened countries, and the consequent democratization of the social structure, new social legislation was gradually introduced to cope with the problems created by the progress of industrialization. Incidentally, this legislation also to some extent benefited the disabled. Thus were laid, during the second half of the nineteenth century, the foundations of the present invalidity relief schemes. These schemes were developing little by little until the first world war ushered in a new concept—that of rehabilitation.

Whereas the concept of invalidity relief tacitly accepted that the disabled person was permanently incapacitated for any work and would remain a charge on the community for the rest of his life, that of rehabilitation is based on the assumption that a disabled person can very often be physically

rehabilitated by new therapeutic methods; and that, in most cases where he cannot be physically rehabilitated to any marked extent, he can be socially rehabilitated by suitable training for some kind of work which will ensure his subsistence and reintegrate him into the community. It was natural that such a concept should have been born during the first world war, when thousands of disabled men were invalided out of the armies each month.

The first rehabilitation centre to become widely known was founded during the 1914-18 war by Robert Jones at Shepherd's Bush, London. Here men disabled during the war were trained, chiefly in specially chosen work, at small workshops. The results proved so promising that H. E. Moore in 1925 opened a similar centre at Crewe, England, planned on more advanced lines, where disabled railway workers were re-trained.

But these pioneering efforts were no more than the isolated endeavours of individuals. Rehabilitation as a medico-social method of treatment of the disabled did not really come into being until about fifteen years ago. And there is no doubt that this development was prompted by the enormous increase in the number of disabled persons due, first, to the second world war, and then to the spectacular expansion of motor traffic with its heavy toll of accidents after the war. To put it bluntly, rehabilitation was not really taken up until it became attractive as an economic proposition—until it was realized that in a modern expanding economy rehabilitation could show a profit, whereas invalidity relief could only show a loss.

In its present form rehabilitation was developed mainly in the United States and Britain during the latter part of the second world war. A special tribute is due to the Royal Air Force centres in England, which achieved such excellent results that they became a model for rehabilitation centres in other countries. During the following years some influence was felt from France, Scandinavia and the Benelux countries. In Scandinavian countries, in particular, the feeling is very strong that the disabled should, as far as possible, be reintegrated into the community to become 100 per cent socially efficient citizens. There is even an inclination to eschew the word 'rehabilitation', which seems to carry an element of lost prestige, and to use instead the word 'revalidation', which conveys to the disabled a sense of being restored to full social fitness.

WHAT IS REHABILITATION?

There are differences in opinion as to what methods and treatments should be included under the general heading of rehabilitation; there is, however, general agreement that the treatment generally known as rehabilitation should be started as soon as possible after the patient's admission to hospital.

The first part of the programme is undertaken by physiotherapists. The

treatment consists in an intensive exercise therapy, instruction in the use of the locomotive system, massage, baths, electrical treatment and medical treatment. As regards exercise therapy, a tendency has recently manifested itself to arrange this treatment for groups of patients suffering from the same disease or form of invalidity. In this way a certain element of competition is introduced, with the advantage that it not only stimulates the individual patient to a maximum of exercise, but also helps to simplify and rationalize the work for the staff. In its best form, group therapy is organized in the following way. The leading physiotherapist organizes and arranges the special exercise programme that is suited for a particular group of patients. He or she is assisted by one or more trained physiotherapists who want to specialize within that particular branch of therapy. They correct the individual patients within the group for any faulty positions or movements during the group exercise.

In cases of chronic disorders of the central nervous system, in particular, an increasing number of gymnastic patterns are gradually introduced with the aim of furthering the rehabilitation of patients. This form of treatment is co-ordinated with, and sometimes followed by, corrective therapy which aims at developing the daily efficiency of the patient in managing his every-day problems, such as hygiene, washing, dressing and undressing, getting out of bed or out of a bath chair, or simply getting up from an ordinary chair, etc. Therapy then progresses to include exercises for walking up and down stairs as well as for more complicated movements.

Working on parallel lines with the treatment mentioned above is the occupational therapy unit, which must be considered an integral part of the department of physical medicine and rehabilitation. Occupational therapy must be of such a character as to rouse the patient's interest and to divert his attention from his disability and its consequences. On the other hand, this form of therapy must not require great physical or mental exertion, so as not to fatigue the patient. It is rather in the nature of a nerve sedative, aiming at diverting the patient from a potential neurotic fixation that may develop as the result of the illness and its consequences. In its best form, this kind of therapy therefore takes the character of some light craft such as sewing, a light handicraft such as cutting out things, braiding, woodcarving and the like. The aim of this *temporary* occupational therapy in the acute phases of the disease should be to work the patient out of his state of ego-centricity, to develop and increase coarser as well as finer occupational patterns for the locomotive apparatus, to train up the rate of speed, accuracy and power of endurance of the neuro-muscular apparatus, to enable the patient to manage more quickly for himself during the later and more active stage of the convalescent period, and finally to train the patient in the use of protheses, crutches, bandages and other surgical appliances.

When the more acute stage of the disease is past and the patient has

reached a condition where preparations for helping him to return to the troublesome circumstances of everyday life can begin, the problem often arises whether the patient should be trained to resume his former occupation, or whether some new occupation should be found for him, having regard to his invalidity. In the former case the occupational therapy is replaced by a more precise training with a view to teaching the patient to adopt the working position he will have to take up on his return to normal work. This may have to be followed by a selection of gadgets, and instructions in their use to facilitate his work. Finally, he may have to be trained in the rehabilitation workshop in the use of the machinery and instruments he will have to operate in his work.

In the second case, where a new occupation must be chosen, it will often be necessary, before the rehabilitation training enters its final stage, to call in psychotechnic assistance in order to choose an occupation which takes account not only of the degree of disability of the patient, but also of his former social standard, as well as of his present possibilities for earning his livelihood, of his interests and of his psychological outlook. It is only then that the actual choice of an occupation can be made, and the training of the patient be organized within this framework, while the social workers attached to the department start looking for a suitable job for him.

However, it must be borne in mind that, no matter how great the effort to duplicate future working conditions, the apparatus of the rehabilitation workshop will never quite correspond to the apparatus the patient will find at his actual workshop. There will be a period of transition when the patient will continually need assistance—medical, psychological, technical, physiotherapeutic. It is therefore necessary to maintain a fairly large out-patients' service within the rehabilitation department so that, during some fixed period (up to six months, for instance), the patient has the possibility of consulting the department and seeking assistance on problems and difficulties he encounters in his work.

This short description of the main principles on which rehabilitation is based by no means covers all the various methods and treatments that come under this heading. Some of these will be mentioned below in connexion with the types of cases calling for rehabilitation.

CASES CALLING FOR REHABILITATION

An ever-increasing number of cases undoubtedly require certain well-defined rehabilitation programmes. In most of these cases, the medical or surgical stage of hospital treatment is of relatively short duration, the main emphasis of the treatment shifting to the rehabilitation department.

A classification of the different illnesses or injuries requiring rehabilitation

is difficult because cases may vary considerably within the same group, thus raising widely varying and often complicated rehabilitation problems. However, to facilitate a survey, an attempt will be made to define broadly the important groups of disabilities which make the greatest demands on the planning of rehabilitation departments. For some of the groups a detailed discussion of the individual disorders is unnecessary; for other groups, various sub-divisions should be distinguished in so far as rehabilitation is concerned.

Traumatic injuries to the extremities. With the progress of modern orthopaedy and surgery of the extremities, the chances of rehabilitating patients in this category have improved considerably. This is particularly true of cases of tendon transplantation, muscle transplantation, suture, etc.

Traumatic injuries to the central nervous system. This group includes more particularly patients with the following conditions: concussion of the brain, sequelae of brain concussion, trauma of the head, cerebral haematoma, post-traumatic cerebral contusion, the post-traumatic cerebral syndrome, injuries to the pyramidal tract, and aftereffects of cranial nerve lesions.

Traumatic injuries to the peripheral nervous system. This group mainly comprises patients with various forms of peripheral paralyses. The conditions may vary from very mild forms of reduced tonus in a muscular group to massive atonic paralyses.

Rheumatic diseases. Rehabilitation is certainly indicated, even if initiated in the acute stages and in cases where there are clinical prospects of a long progressive disease, such as recurring rheumatic fever, certain forms of polyarthritis, and collagen diseases. Despite the progress of chemotherapy and of the more recent hormone therapy, it appears that a large proportion of patients in this group are becoming increasingly incapacitated, and the conclusion must be drawn that treatment which will benefit the patient in the long run will consist mainly in physiotherapy initiated at the most suitable time, combined with well-planned occupational and rehabilitation therapy. This treatment applies not only to arthritis patients, but also to arthrosis patients.

Disorders of the respiratory passages. These are both surgical and medical cases. The latter are mainly patients suffering from chronic bronchitis, atelectasis, bronchiectasis, pulmonary emphysema, bronchial asthma, and also those suffering from disorders due to faulty carriage or thorax deformities. The surgical cases in need of rehabilitation are mainly patients having undergone thoracic surgery for diseases such as cancer of the lung, empyema of the chest, pulmonary tuberculosis and pulmonary abscesses. The rehabilitation

begins with pulmonary physiotherapy. This is followed by ordinary physiotherapeutic training, after witch the patient is fit for participating in rehabilitation work.

Disorders of the vascular system. The treatment following thoracic surgery in pulmonary diseases applies even more to heart patients, and the training schedule for patients having undergone heart operations largely follows that for those having undergone lung operations. A number of patients with other vascular diseases are incapacitated to a varying extent, and a good many scientific studies have shown the necessity of rehabilitating this group of patients.

A special group of patients may be mentioned under this heading—the cases of cerebral haemmorrhage. This disease might equally well have been placed under the heading of disorders of the central nervous system. The reason why it is mentioned under vascular diseases is an aetiological one: the causes of cerebral haemorrhage in 88 per cent of the cases are vascular, while traumatic causes amount to 7.5 per cent only, tumours to 2.5 per cent and infections to 2 per cent. However, in the age group from 15 to 25 years, the chief causes of cerebral haemorrhage are traumatic and not vascular.

Tuberculosis. After recovery or discharge from hospital, patients are often physically too handicapped to resume work. The main task of the rehabilitation department consists in making them fit to stand an eight-hour working day. They are trained under a physiotherapeutic programme to meet such respiratory demands as the future job is expected to make, and as far as possible are given an occupation in healthy surroundings. Some of the training can take place in the open, in the form of cycling, weight-lifting or organized games such as tennis, golf, ball games, etc.

Amputees. Leg amputees can now, under a rational training programme, be restored to almost 100 per cent efficiency in productive life, except for patients affected by accompanying diseases that aggravate the disablement, or patients so advanced in years as to be unable to profit from a re-training programme.

Arm amputees present more serious problems, though here too, important results have been achieved in more advanced countries, owing mainly to the better understanding by employers and authorities of the necessity of restoring such patients to normal working life. With the progress of rationalization in industry (the development of automation, for example) the possibilities of employing this particular group of disabled persons will increase considerably.

The training programme for amputees is in most cases well defined: physiotherapy combined with occupational therapy, exercises in swimming

pools, resistance exercises, etc., render the stump fit for an artificial limb; then follows training in the use of a provisional prosthesis, and lastly the rehabilitation is completed by a set of progressive exercises in the use of the final prosthesis.

Diseases of the central or peripheral nervous system. Conditions resulting from acute or chronic diseases in the central or peripheral nervous system are certainly amenable to rehabilitation treatment. In this connexion, it may be useful to comment in some detail on a special category of patients who in recent years have engaged the attention of doctors, therapeutists and social workers more than any other group—patients with cerebral palsy.

This group is generally characterized by neuromuscular disorders due to injuries to the brain in the foetal stage, during birth or in early childhood. Formerly these disorders were known under the name of 'spastic paralysis', but today the term 'cerebral palsy' is used almost universally to describe patients with athetosis, ataxia, rigidity, tremor, and atonic conditions. Injury to the brain in children is not always limited to a motor area, the basal ganglia and the cerebellum, but frequently also affects other parts of the brain, with subsequent disturbances of intellect and of the emotional life and perceptive faculties (blindness, deafness, reduced or modified associative faculty).

No definite surgical or neurological treatment offering prospects of steady improvement has yet been developed, but everywhere work—private or publicly sponsored—is in progress for the rehabilitation of these patients. The methods now being studied are very much along the lines of those followed for polio victims (see below). A new method of neurosurgical treatment of cerebral palsy recently developed at the Bellevue Hospital, New York, consists in chemopallidectomy, i.e., the chemical destruction of a small area of the brain known as the *globus pallidus*. The results have been so promising that this form of treatment has been taken up by several of the large neurosurgical departments in Britain, Scandinavia and Western Europe.

However, in spite of the great hopes to which this new method has given rise, it is obvious that a fairly large proportion of patients will not be amenable to this form of treatment, and it would therefore be wrong to slacken the efforts to develop the branch of physical medicine which aims at rehabilitating this group of patients. The pattern of the rehabilitation exercises is fairly complicated; it theoretically aims at creating new transmission paths for the muscular impulses in the central nervous system in such a way that these new impulse paths bypass the injured parts of the central nervous system. The pioneers in these patterns of exercises were the Americans Phelps, Kabat and Temple Fay, but many other workers have followed up this basic method, and new systems are continuously being evolved.

Geriatric patients. Many elderly people may be trained to take up productive work, provided they are not so incapacitated by disease that rehabilitation would be illusory. Psychologically, it is far better to keep them in some kind of productive work rather than cut them off from employment at an age when they can still do certain jobs. The difficulties in finding employment for this group of patients arise from economic and social rather than from medical factors—the competition of younger people. These questions have now been taken up on a rational basis, and it may be expected that gerontology combined with extended physical medicine will become an important branch of medical knowledge in the near future.

Poliomyelitis. It was poliomyelitis which originally sowed the seeds of rehabilitation work; the great epidemics left in their wake such great numbers of patients presenting all forms of disablement that it became necessary to do something about it. The work has borne fruit for the individual patient, for the community and for those who tackled the problem. In most countries rehabilitation from poliomyelitis has now become so systematized that there is hardly any reason to comment upon it in any detail.

THE DEMAND FOR REHABILITATION

What do the cases described above amount to in terms of numbers of people who are in need of rehabilitation? According to a report of the British Medical Association, 25 per cent of patients who pass through the departments for acute cases in a general hospital are in need of rehabilitation. A report from the Swedish Health Office gives approximately the same figure. On the other hand, in a paper read to the Second International Congress of Physical Medicine in Copenhagen in 1956, Dr. Backer of Copenhagen concluded, on the basis of a statistical study undertaken in a Danish County Hospital, that only about 10 per cent of the patients would have benefited from rehabilitation treatment.

It must be emphasized, however, that the need for rehabilitation is not something that can be assessed absolutely, without reference to social structure and social services. In fact, the need varies from country to country according to the degree of availability of social insurance, and particularly of invalidity relief. In countries where invalidity relief is widespread and relatively high, the *apparent* need for rehabilitation is felt to a lesser extent than in countries where this relief is more restricted in scope and degree, simply because a certain number of disabled people who receive adequate relief are *economically* less in need of rehabilitation than those who do not receive it.

The advantages of invalidity relief are however open to question. When

we have admitted that invalidity relief may be considered a good thing in itself, it is only reasonable to look at the reverse of the medal. The wider the margin for obtaining invalidity relief, the greater the number of recipients, and as the social budgets are already overburdened, the smaller the amount obtained by the individual recipient. The relief often brings happiness at first, but later gives rise to a feeling of bitterness against society, a feeling that the patient has ample time to nurse during his enforced professional inactivity. From the point of view of society, invalidity relief is an unproductive investment, which is justified in extreme cases only, when the problem of invalidity cannot be solved otherwise. It is therefore worth considering whether many of the disabled who live on invalidity relief would not have benefited much more by rehabilitation, which would have enabled them to make a useful contribution to the community in some profession or special work other than that which they were found too disabled to pursue. Nor must it be forgotten that, if the establishment of rehabilitation departments in hospitals is a costly enterprise, at least—in contrast with invalidity relief—it falls within the category of productive investment.

Another factor which makes it difficult to assess the real needs for rehabilitation is the state of the labour market. Clearly, in an economy where there are more jobs than people to fill them, many persons partly disabled and with limited working capacity can still find employment, and are not therefore confronted with serious occupational problems. But when there are more people than jobs, the disabled have to face far greater occupational problems and feel much more acutely the need for, and the advantage of, rehabilitation.

Now Denmark not only enjoyed full employment during the period of Dr. Backer's survey, but it also had—and still has—the widest and the most generous invalidity relief system in the world. It is for these reasons that the apparent need for rehabilitation is lower in Denmark than elsewhere. But if Dr. Backer's statistical analysis is viewed in the light of these two factors, the figure comes much closer to that reported from Britain and Sweden. It can therefore be taken for granted that about a quarter of the patients who pass through the departments for acute cases in hospitals are in need of rehabilitation.

This, undoubtedly, is a high figure. What then are the causes that have so greatly increased the need for rehabilitation in the course of the last generation?

In 1950, at the close of the first half of the twentieth century, a group of elder statesmen from all walks of life in the United States were asked to comment on the most significant changes which, in their opinion, had occurred during the first 50 years of this century. Most answers pointed to the social impact of such technological advances as nuclear energy, mass communication, rapid transportation. To Mr. Bernard M. Baruch, however,

the phenomenon which held the greatest significance for the present and future generations was the fact that, in the developed parts of the world, man's life expectancy had increased from 49 years in 1900 to 67 years in 1950. In the seven years which have elapsed since then, it has been further extended, and now reaches the legendary three-score-and-ten.

This rapid increase in the number of older people raises medical, social and economic problems. In a paper read to the Second International Congress of Physical Medicine in Copenhagen (1956), Dr. Howard A. Rusk of Bellevue Medical Centre, New York, reported that the average number of days of hospital care of persons over 65 years of age is double that of those under 65. Moreover, many of these patients are chronically disabled and present conditions in which specific medical treatment can be of no value. What they need is a co-ordinated programme of rehabilitation which will teach them how to live and to work as effectively as possible within the limits of their disability. This is all the more important since, in many countries, the care of the aged tends, for various reasons, to shift from the individual family to public authorities.

But quite apart from the fact that the proportion of patients from the older age groups has been steadily increasing, there has also been a marked shift in the character of the diseases for which patients are hospitalized. This trend, brought about mainly by the discovery of chemotherapeutic and antibiotic agents, is well illustrated by the following table, which gives in percentage figures the causes of death in 1921 and 1954 respectively.

TABLE 1. Causes of death in Denmark[1]

	1954	*1921*
Violent death	7	3
Cancer	21	12
Diseases of the heart	27	10
Vascular diseases in the central nervous system	13	5
Tuberculosis	1	9
Other infectious diseases	1	7
All other death causes	30	54
Total	100	100

The increase in violent deaths and deaths from cancer, heart diseases and vascular diseases in the central nervous system is offset by the decrease in deaths from all other causes, particularly tuberculosis and other infectious diseases. Table 2 illustrates the change in the nature of the diseases treated in hospitals in 1945 and 1953.

1. *Medicinal-statistike Oplysninger,* 1921 and 1954, Copenhagen.

TABLE 2. Survey of certain diseases treated in Danish hospitals[1]

Main diagnoses	Absolute figures		Per 1,000 patients	
	1953	1945	1953	1945
Old age diseases	804	538	1.6	1.3
Diseases in the locomotive apparatus	22 231	19 198	45.3	44.7
Infectious diseases	20 113	47 603	41.0	110.8
of which venereal diseases	*870*	*9 085*	*1.8*	*21.1*
Congenital malformations	2 614	1 944	5.3	4.5
Diseases in the nervous system chiefly expressed in physical symptoms	14 739	9 927	30.1	23.1
Traumatic lesions	43 957	31 432	89.6	73.2
Total	104 458	110 642	212.9	257.6

As can be seen from the above figures, during the eight years covered by the survey the incidence of infectious diseases fell by almost two-thirds, while that of congenital malformations, traumatic lesions, diseases in the locomotive apparatus, and diseases in the nervous system with chiefly physical symptoms—all diseases which in greater or lesser measure call for rehabilitation—is on the increase. In fact, of all the diseases and disabilities requiring rehabilitation, tuberculosis is the only one which is rapidly declining. Poliomyelitis may be expected to follow suit in the not too distant future, owing to the development of polio vaccine. But all other categories are on the increase. Thus, in cases of disorders of the respiratory passages, surgical patients in need of rehabilitation are mounting in numbers owing to the advance and wider use for thoracic surgery. The number of amputees is likewise increasing, not only because of the rapid development of motor traffic, but also because of new trends in orthopaedic surgery. There is also a more realistic attitude on the part of vascular surgery towards amputation, and the view is gaining ground that amputation is, after all, preferable to incapacity for life owing to a peripheral chronic vascular disease.

The number of hemiplegics is also steadily increasing, mainly because of the rising pressure of modern life. In his place of work, the individual is exposed to an ever greater strain, the tempo in industry and commerce has quickened, the competition among trades and among individuals has become keener. In a paper read to the Second International Congress of Physical Medicine, G. Gingras and his co-workers of the Rehabilitation Institute of Montreal, Canada, reported that hemiplegics represented 16 per cent of the total number of patients in need of rehabilitation. The disease is still much more common in men (65.8 per cent) than in women (34.2 per cent). On the other hand, in recent years the age distribution has shown a tendency to

1. *Medicinal-statistike Oplysninger*, 1945 and 1953, Copenhagen.

vary: formerly cerebral haemorrhage was confined mainly to the older age groups; now it tends to affect ever younger age groups. The figures from Canada show that over 30 per cent of cases occur before the age of 45; what is even more remarkable is the fact that the age group of 15-24 years should account for as much as 3.8 per cent of the cases. Cerebral haemorrhage has a tendency to affect certain occupational groups more frequently than others. The paper mentioned above shows the following percentage distribution: housewives 24.9 per cent, semi-skilled workers 24.45 per cent, unskilled workers 21.5 per cent, skilled trades 16.45 per cent, while people engaged in professions represented only 7.2 per cent of the total, and people who had never worked only 5.5 per cent. Economic factors also seem important in the aetiology of the disease: people with independent means are affected much less frequently (26.4 per cent) than those who are financially dependent (73.6 per cent).

It is interesting to note the results of rehabilitation as reported by Gingras and his team. Out of a total of 237 cases of cerebral haemorrhage, 63 were so seriously affected that they were found unfit for rehabilitation. Of the remaining 174, 36 patients were reinstated in their former work and 20 in some other, more protected work. There was also a notable improvement in the degree to which the other patients were independent of help in their daily activities. Compared to the means devoted to the rehabilitation of poliomyelitis patients, relatively little is spent on hemiplegics, despite the fact that hemiplegia is more widespread, is steadily increasing, and offers better chances of rehabilitation over a much shorter period of treatment.

Lastly, a word should be said about cerebral palsy. The reported incidence of this disease varies considerably, and it is not clear whether it is on the increase. Following a survey of several communities in the eastern part of the U.S.A., it was estimated that 7 children with cerebral palsy were born each year per 100,000 population. The figure reported from Sweden was one child annually per 100,000 population. A study in Schenectady County, New York, made in 1949, resulted in a figure of 512 children per 100,000 population (5.9 cases per 1,000 births). The Connecticut State Department of Health reported 228.6 children with cerebral palsy per 100,000 population of less than 21 years in Connecticut. Returns from England show one case per 1,000 schoolchildren, those from Scotland 1.2 per 1,000 schoolchildren. A survey recently undertaken by Dr. Paul A. Nelson, of Cleveland, Ohio, and presented at the Second International Congress of Physical Medicine shows that the incidence of cerebral palsy was 1.4 per 1,000 population of less than 20 years of age in the Greater Cleveland area. This figure roughly corresponds to that found for the Scandinavian countries, particularly Denmark.

As can be seen from the above figures, the number of patients in need of rehabilitation is high and is steadily increasing, owing partly to the strain and stress of modern life, and partly to the progressive ageing of the population due to the tremendous advances in medicine in the course of the last 50 years. Lacking specific measures for the cure of many of the chronic diseases, medicine must look to rehabilitation to teach the disabled to live and work as efficiently as possible. Until medicine finds specific answers to the problems of the diseases of the heart and circulation, rheumatic fever and arthritis, cerebral palsy and other crippling diseases, it must utilize the techniques of physical medicine, psychology, social service, vocational counselling and the para-medical specialities to rehabilitate physically—and therefore emotionally and socially—the ever-growing mass of disabled people. Until recently, medicine looked upon rehabilitation as an extraneous activity connected with social work and vocational training; today it is beginning to recognize that medical cure cannot be considered complete if the patient left with a residual physical disability has not been rehabilitated. It is therefore not without interest to consider the problems involved in the setting up of a rehabilitation department.

ESTABLISHMENT OF A REHABILITATION DEPARTMENT

The establishment of a rehabilitation centre often presents difficulties in countries where this problem has not received previous attention. The best work on this subject so far published is that of the Baruch Committee on Physical Medicine.[1]

A rehabilitation department should preferably be attached to an already established general hospital; the latter should be of such a size as to include several independently functioning special departments, so that the rehabilitation department may benefit from the consulting activities of the hospital staff of specialists. It is desirable, in particular, that the hospital include, in addition to the general medical and general surgical departments, a neuromedical, a neurosurgical, an X-ray and an orthopaedic department, and that psychologists and professional social workers be attached to the hospital.

Admission to the rehabilitation department will normally take place via the other hospital departments, but the right to refer patients directly to the rehabilitation department should also be granted to medical practitioners and certain organizations and institutions, such as trade unions, out-patients' clinics and dispensaries, and smaller general hospitals within a reasonable distance from the rehabilitation centre. The patient first undergoes a normal

1. *Organization Chart of a Rehabilitation Centre*, Baruch Committee on Physical Medicine, New York, 1950.

medical examination, psychotechnic tests and has a consultation with the social worker. After a conference between these three sections, the patient is referred to the department proper to start the treatment. Some patients may be so incapacitated as to necessitate transfer to the bed ward of the rehabilitation department. As a rule, however, there are not many such cases, and the ward need hardly have more than 20 to 30 beds. In fact, if the general hospital concerned already has departments for rheumatology and gerontology, the number of beds in the rehabilitation department can be further reduced.

A well-equipped rehabilitation department must embrace a complete department of physical medicine, with sufficient space for the equipment of cubicles for massage, individual exercise therapy, short-wave diathermy, and for other electric training appliances. It must also have full facilities for swimming-pool exercises and for individual hydrotherapy. The department should further include a large gymnasium, which may be partitioned off into several smaller gymnasia for the general physical training of patients and for group therapy for spastics, amputees, hemiplegics and patients needing respiration exercises. There should also be an occupational therapy unit, offering consulting service to the other hospital departments and to bed patients in the rehabilitation department.

The rehabilitation department proper may conveniently include four chief sections. One is built like an apartment, containing a living-room, bedroom, kitchen and lavatory. It is in fact a training apartment, amply provided with all sorts of gadgets, so that the patient can rapidly find out which gadgets are necessary to him in his particular situation. The social worker then contacts the housing authority or the patient's home with a view to providing such gadgets or possibly re-equipping the home. This section of the rehabilitation department is chiefly reserved for housewives, or men who are so incapacitated that they can only cope with housework and must therefore receive the appropriate training, while the woman does the outside work.

The other three sections of the rehabilitation department are most conveniently divided into premises suitable for clean, dirty and noisy work respectively, including store rooms, shower baths, lavatories, office and day rooms for the staff, and perhaps a dining-room for patients. The type of work for which the patients are trained on these premises depends of course on the local employment conditions; it is therefore impossible to lay down hard and fast rules for the equipment of these premises. Certain lines, however, are followed almost everywhere. Thus the premises for clean work are usually equipped with implements for lace-making, hand looms, sewing machines, tools for cutting-out, office machines such as typewriters, book-keeping machines and calculating machines, equipment for calico printing, plaiting, bone-carving, etc. Premises for dirty work might have a joiner's workshop, grinding and polishing machines, a lathe, a vice bench, soldering

and welding equipment, appliances for precision mechanics, watchmaking, radio and television mechanics, etc. The premises for noisy work usually concentrate on shoemaking, manufacture of surgical appliances, bookbinding, work with cardboard and plastics.

The rehabilitation department should establish a close co-operation with the workshops and working places which are attached to the hospital and to which partially trained patients can be sent for temporary service with a view to completing their training—primarily the hospitals engine room, painter's shop, garden, laundry, photographic workshop and, possibly, the electrotechnical laboratory. On completion of this training, the patients discharged from the rehabilitation department fall into one of the following four categories: full employment, selective employment in a protected trade, conditioned fitness, and domestic work. However, as has been pointed out earlier, the patients must have facilities for consulting the rehabilitation department and seeking assistance on problems and difficulties they may encounter in their new occupation.

As for the staff of a rehabilitation department, it is imperative that the head be a fully qualified specialist in rheumatology, physical medicine and rehabilitation, and that he be assisted by a qualified medical staff training for that particular speciality. This training still varies considerably from one country to another, and the International Federation of Physical Medicine at one of its board meetings decided to promote the standardization of this specialized training.

The staff includes, of course, a number of physiotherapists. In addition to those who have received the general standardized training, the rehabilitation department must have at its disposal physiotherapists with specialized training in the following branches: pulmonary physiotherapy, treatment of flaccid and spastic pareses, treatment of amputees, relaxation therapy, bath and pool treatment, occupational therapy. The personnel also includes psychologists, social workers, nursing staff and technical advisers. Lastly, the rehabilitation department must have at its disposal consultative help and guidance on questions of neuromedicine, neurosurgery, orthopaedic surgery, radiology, medicine, surgery, and gerontology. Only then can it be said to provide a complete rehabilitation service.

CONCLUSION

As a result of the strains and stresses of modern civilization and of the progress of medical science, there has been a remarkable shift in the nature of the diseases which afflict man. In the developed parts of the world, the acute, communicable diseases are on the wane, giving way to slow and insidious chronic diseases which leave many disabilities in their wake. Until

medicine has found specific remedies for these chronic diseases, it must rely on other techniques to solve—at least partially—the problems they raise. These are the techniques of physical medicine, psychology, social service, vocational counselling, and the para-medical specialities, which together constitute a socio-medical method of treatment of the disabled known as rehabilitation. Its aim is to rehabilitate the disabled physically, psychologically and socially, so that they can be reintegrated as useful members into the community.

There has been a great surge of interest in rehabilitation since the end of the second world war, and this interest is by no means limited to the few countries of North America and Northern Europe which were the first to develop this new technique; rehabilitation centres are being set up in Brazil, Venezuela and Colombia, in Lebanon and Egypt, in India, Indonesia, the Philippines and Korea. In underdeveloped areas also, the concept of the dignity of man and of the value of the individual which is beginning to emerge is finding its expression in the development of rehabilitation centres for the crippled and the disabled.

However, rehabilitation is not only an ethical answer to the problem of physical disablement; it is also an economic answer to the grave social problem raised by the steady increase in the number of disabled persons. For, unlike invalidity relief, rehabilitation is a productive investment. But it can be fully productive only if governments, employers' organizations and trade unions are made to realize that rehabilitation has ethical and human as well as economic and social aspects.

CRITERIA FOR THE APPLICATION OF RESEARCH RESULTS

by

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INTRODUCTION

One of the inescapable consequences of our scientific civilization is that the natural sciences and their applications are becoming increasingly influential in the political, economic and social spheres. A modern society must therefore face the implications of the results of research and try to evolve suitable criteria for their economic and social usefulness.

This, of course, holds good for fundamental as well as applied science, though it is not always easy to see where the one ends and the other begins. No doubt, at one end of the scale fundamental science can be defined clearly and precisely, and so can applied science at the other end of the scale; but between the two there is a large middle area of overlap, and the whole thus resembles a spectrum with the colours merging progressively into one another.

The whole process of applied research consists in pin-pointing the objectives and in making appropriate selections between several possibilities at each stage of progress so as to direct the maximum effort towards a well-defined goal. It is to this selection and effort that economic and social criteria must be applied.

By contrast, no such precise criteria can be brought to bear on the usefulness of pure or fundamental research, which can be neither directed nor controlled, but must be inspired and conceived so as to give the fullest scope for imaginative and creative thinking. But the absence of systematic criteria does not absolve those directly concerned with, or responsible for, fundamental research from attempting to visualize or even to assess the possible implications and consequences of a particular line of work. There is always a time-lag between the emergence of a new idea in the laboratory or in the scientist's mind and its large-scale technological application, and though this time-lag has tended to become ever smaller since the beginning of this century, it still leaves scope for trying to assess the social and economic implications and making the necessary adjustments. There are welcome signs

that scientists as well as administrators are beginning to appreciate this point and that the dangers of an 'ivory tower' attitude are being more fully realized.

Although this article is concerned primarily with research in the civilian sector, a few words should be said in connexion with research in the military sector, not only because it is progressing rapidly and yielding spectacular results, but also because its implications and usefulness in the civilian sector cannot be denied. Research for defence purposes presents a curious paradox: its main stimulus is to get practical results which, by their very nature, are anti-economic and anti-social; and the criteria of usefulness which normally apply to civilian research have by and large no relevance to research for defence purposes. However, the fact that those responsible for defence research have more or less definite policies and objectives and are constantly scrutinizing what is scientifically and technologically feasible in relation to these objectives, without too much regard for cost or for indirect consequences, does create conditions in which pure and applied efforts are mutually stimulated, and corresponding fruitful results achieved.

In the civilian sector the position is much more complex, because objectives are often less clearly defined, while economic and social considerations become the predominant criteria. To utilize the results of fundamental research for the material benefit of the community, there must be reduction to practice, and thereafter selection of what is most suitable and advantageous for further development and utilization. The process which finally results in full-scale exploitation is thus composed of several stages, at each of which the target is narrowed down and the effort in time and cost increased several fold. At the same time side issues may arise and by-products appear.

All this must be taken into consideration, and as total resources are limited, a more and more stringent selection of what to continue and what to postpone or to drop altogether is necessary at each stage. This is all to the good, because the number of new ideas must necessarily be far greater than that which is ultimately used, so that there is not only a provision for wastage, but also a reserve for future possibilities. These possibilities may arise when an ancillary discovery, for example, facilitates the 'reduction to practice' or makes practicable a potential product or process, or when a change in economic conditions opens up new technological possibilities.

Growing complexity at each stage means that the whole process leading to full-scale exploitation takes years rather than months—which is fortunate, as it gives the opportunity of assessing, at least approximately, the economic and social implications of the contemplated technological change and of trying to make the necessary adjustments. In this connexion, it is important to appreciate that imaginary implications may have as much or more effect than real ones. Fears of mass redundancy or expectations of unlimited leisure arising from scientific discoveries and technological developments may lead to all sorts of unfounded speculations—and foolish decisions. Common sense

alone is not enough; what is needed is patient exploration and thorough study of the various possibilities, however speculative these may appear at times.

A few examples selected from various fields illustrate the general arguments mentioned above.

SOME EXAMPLES OF NEW TECHNIQUES

It is known that certain bacteria in the soil convert atmospheric nitrogen into nitrogenous compounds useful to plant life, while other bacteria decompose such compounds, liberating nitrogen. In nature these two processes are roughly in balance. Their exact mechanism is now only beginning to be understood. Now the world's biggest food deficiency is the nitrogenous complex—protein; in order to obtain adequate quantities of it in vegetable and animal form, enormous quantities of nitrogen fertilizers, requiring many millions of tons of fuel for their manufacture, are used every year. But fuel is becoming scarcer and more expensive, and this trend is not likely to be reversed in the near future. It is clear therefore that, if ways and means could be devised for cultivating the most effective strains of nitrogen-fixing bacteria and stimulating them to an increased output, while suppressing the reverse process, a great step would have been taken towards solving the world's food problem.

Unfortunately, there is relatively little research on this subject, and virtually none of it is co-ordinated. So many different aspects—chemical, biological, botanical, ecological, physical—are involved, that only a long-term 'combined operation' could hope to achieve success. There is no doubt a stimulus—the economic need to produce more protein without depleting the world's resources of mineral fuel—but it is much easier to organize a great combined operation in a well known practical field than in an enterprise which, from a scientific point of view, is still largely fundamental.

The large deposits of very rich iron ore in the far north of Sweden are likely to be exhausted in a definite number of years. Consequently, the community established around these deposits, and enjoying thanks to them a high standard of living, will ultimately have to be either transported elsewhere or found other occupations. As the iron ore industry is very rich, ample funds are available and the sites are well supplied with up-to-date services. The next logical step would be to mobilize all the resources of science and technology in order to find out what would be the best type of alternative activity under the peculiar circumstances (climate, human and material resources), and draw up a plan of investment spread over a definite number of years. In fact, what is needed in this particular instance is a research and development

organization with a definite plan of objectives and time schedule, with the industry providing finance and scientific manpower, and the State creating the appropriate economic and social climate. Whether this could be done solely on the basis of scientific and economic criteria, without giving rise to political issues, is however an open question, though the economic and social need of such a development scheme is evident enough.

Reserves of good quality coking coal in Europe are dwindling, while demand for steel is rising, according to the forecast of the European Coal and Steel Community. There is thus a prospect of a shortage of indigenous supplies of coke within a measurable time, and it is hoped that the shortage will be made good by imports from the U.S.A. However, a number of ideas—some of them very ingenious—have from time to time been put forward to reduce, or even abolish completely, the need for coke in steel production. These include using an auxiliary source of heat or a composite coke of ground iron ore and ordinary coal or even a gas stream only with powdered ore, as in cycle-steel. But, so far, none of these ideas has gone beyond the stage of experiment. Yet the European Coal and Steel Community has enormous resources in finance, skilled manpower and research facilities among its members. It could initiate a large-scale plan of applied research for an efficient process (or processes to fit in with local conditions) which would greatly diminish or altogether abolish the need for coke in steel manufacture. There is as yet no clear sign of such research being undertaken, possibly because it would ultimately involve the planned use of fuels other than coal, and might thus raise the politically difficult issue of wider integration than that based on coal and steel alone. If so, this is an illustration of the irrefutable logic of technological integration cutting across politico-economic considerations.

Sweden beyond the Arctic Circle possesses an area with fertile soil and just the right rainfall, in quantity and seasons, to make full use of the periods of continuous daylight for crop growing. By a suitable selection of crops (cereal, vegetable, fruit), new genetic strains, and special methods of pre-treatment to make the fullest use of these conditions, a wide range of high-quality produce can be obtained. This technique makes it possible not only to increase the country's overall supply, but also to extend the season for vegetables and soft fruit, thus raising living standards over wide areas of the country.

In Israel a numerous and highly developed community is settling in a very small and largely barren country, where many of the means of subsistence —water, in particular—must be produced artificially at great expense of fuels. And as all fuel supplies must be imported, the already heavy trade

deficit is thus burdened still further. Fortunately, the high amount of sunshine (which is, in fact, a cause of the aridity of the country) is available as a potential source of energy. No doubt, efficient solar engines are complicated and costly, because they require elaborate apparatus to attain the high temperatures which are necessary. But it is possible to build low-grade solar heat absorbers for steam generation in standard, low-pressure boilers, the steam then being superheated for higher thermodynamic efficiency with comparatively small quantities of oil. Such a method could supply substantial amounts of power at a relatively low cost. In fact, applied research and development are now being successfully undertaken to solve this technological problem imposed by the economic and social needs of the area.

The rapid spread of the electronic computer to more and more fields is raising a number of major economic and social problems. Fortunately, it looks as though some at least of the factors which govern the construction and use of computers may also favour a solution of the problems they raise.

At first essentially a tool for rapid calculations, the electronic computer is now being adapted for all kinds of operational control, for clerical data processing, and even for what may become its most important function—rapid and accurate assessment of commercial risks. Although research on the design and utilization of computers is proceeding rapidly, the process from design, via development to ultimate production is slow, partly because of the intricacy and high cost of this new equipment, and partly because of shortage of the highly specialized personnel which it requires. There is thus a time-lag which can be utilized for assessing the economic and social implications of this new technique and preparing for the changes which it is bound to produce.

The first, and perhaps the most difficult, step in this direction is to exorcize the ghosts of 'push-button factories', 'mass redundancy', etc., which cloud judgement just when and where it is most needed. In the first place, the very application of computers to industrial and commercial operations will require new and highly specialized manpower. In the second place, many industrial and commercial enterprises, owing to their size or the nature of their operations, will be unable to use computers, but might well benefit from the greater efficiency and smoother operation of those who do; consequently, they may increase their volume of business and offer more and better employment.

The overall consequence would thus be a big expansion of demand for highly qualified manpower and perhaps even a general increase in employment. But it would also mean greater mobility of labour and greater fluidity as between types of job. It would thus be a challenge to deployment and training of manpower alike. In the case of highly developed countries with a static population, a large-scale use of the computer technique, if properly

planned, could be the key to continued rise in production and consumption —i.e., continued rise in living standards—without the risk of inflation, which is an ever-present danger of full employment. In the case of countries with a growing population, and consequently a continuously increasing demand for basic goods and services, it could provide the means for maintaining basic needs, and also for training personnel for more highly skilled jobs.

OPPORTUNITIES AND LIMITATIONS

The above examples taken at random illustrate the almost bewildering variety of factors which may be relevant to the large-scale application of scientific and technological research results. Circumstances, such as natural or man-made conditions, sometimes impose inescapable criteria and a definite time-limit, while at the same time providing opportunities for concentrating attention and effort. More often, however, there is a choice between a number of possibilities—and the temptation to evade an awkward decision simply by continuing on the old lines in the hope of *solvitur ambulando*. What actually happens in particular fields and in particular areas depends therefore to a large extent not only on the economic, demographic and social factors involved, but also on the psychological outlook of the community concerned.

Thus in the U.S.A., for instance, where everything new is *ipso facto* desirable and anything is worth trying, the motto being 'scrap and replace' without too much regard to possible social consequences, there have been tremendous achievements, but there has also been a tremendous wastage, which few other countries could afford. The fact that the population is growing rapidly and that the younger age groups are becoming larger in relation to the older ones provides not only a surplus of manpower, but widening opportunities for training, so that there is more scope for trying speculative lines. The Russian picture is in some ways similar to the American, but the monolithic structure of the U.S.S.R. and the predominance of political considerations create much greater economic and social changes.

In western and central Europe the problems are different and depend much more on local resources and traditions. The smaller countries, with populations of less than 10 million, often enjoy a high standard of living and can draw upon a large fund of accumulated experience; but as their human and material resources are limited, they cannot afford to advance scientifically and technologically on all fronts simultaneously. They must therefore carefully select their objectives and try to reach them as economically as possible. The larger countries are much less subject to this limitation, but they also must work largely within the framework of their resources and, in some cases, of time-honoured social and political traditions.

It is clear that the problems are fundamentally different according to

whether the population is static or growing. In the former case, there is an absolute limit on the number of man-hours available for economic activity. Further progress and a rising standard of living can only be achieved by cutting down the number of man-hours required per unit of output of goods or services, even if this demands a disproportionately large capital investment. Certain activities will tend to decline, while new ones will arise. This of course implies a high mobility of labour which carries with it problems not only of rehousing, but of regrading, retraining and education. Such problems are not always easy to solve in a community with a stable social structure and traditional industries. To plan and prepare for the change to come, it is therefore all the more important to take advantage of the time which elapses between the conception of a new idea and its full-scale implementation.

Another limitation which applies to countries with a high standard of living and a static population, and which is not always fully appreciated, derives from the fact that the age groups in the schools and universities are not increasing in size, as is the case in the U.S.A. and the U.S.S.R. The countries of western Europe cannot therefore hope to match the Americans or the Russians in the output of scientists and technologists *pro rata* of total population. What is needed is a redistribution of studies within the school and university age groups and a stronger emphasis on the use of accumulated knowledge and experience; in other words, the problem consists in not wasting existing talents, rather than training an abundance of new ones.

Most of these problems do not arise in countries with a rapidly increasing population. Diversification can be achieved by training new intakes, so that changes within the established manpower categories need not be so drastic. On the other hand, an increasing population requires a continuous expansion of basic services (if the standard of living is to be at least maintained), and this expansion must take place well in advance of the increase in earning power, because the expansion of the population will be mainly in the very young age groups which have no earning power. A substantial proportion of the national product must therefore be diverted for this purpose.

Let us examine more closely the situation in a number of selected countries.

NATIONAL PECULIARITIES

As there have been many expert studies on the problems of underdeveloped areas, the following notes will deal mainly with more highly developed countries, though a few indications will be given about the former. The larger areas selected are France, Italy, Western Germany and Britain, each of which illustrates certain particular aspects; the smaller ones are Holland and Norway. Italy is considered as an extremely interesting special case in that

it represents both a highly developed and an underdeveloped country—the North and the South of Italy respectively.

France

France is a country relatively rich in natural resources and conveniently placed for communications. Very high in scientific and technological standards, she is handicapped by a traditionally unorganized agriculture and an industry which has comparatively few large and efficient units. Reconstruction after widespread war damage required thorough planning, and the French achieved a remarkable concentration of scientific and technological effort with careful selection of priorities. This effort is now bearing fruit, as shown by the spectacular increase in industrial productivity.

The French tradition has always been logic and precision of thought, and the application of mathematical criteria to assessing the economic implications of scientific and technological innovations. Consequently, the precise assessment of needs and resources, and their systematic translation into practical steps (the Monnet Plan) have been a feature of French post-war development as far as the public services and some of the main industries are concerned. A striking example of the carefully phased policy of manpower saving by means of technological improvement is provided by the French Railways, which have taken every technological step forward only when the manpower implications have been assessed and the necessary measures taken to cope with them. As a result, productivity has doubled, while manpower has been reduced by 30 per cent in comparison with what it was before the war—and without any awkward redundancy problems. The process, which is not yet completed, may appear expensive, but the cost is part of the capital investment in technological modernization.

However, this modernization of certain selected public services and industries only accentuates the contrast between the scientifically and technologically advanced sectors of the French economy and the still very extensive area of small-scale obsolete industry, commerce and agriculture, which is a severe brake on the country's economic progress. In this respect, the Common Market will no doubt exert a salutary influence. From the point of view of modernization, the administrative arrangement whereby both the Office of the Monnet Plan and the Conseil Supérieur de la Recherche Scientifique et du Progrès Technique are part of the Prime Minister's Office is a distinct advantage, because it enables the two of them to establish close contacts at working level.

Western Germany

The war deprived Germany of many of its industrial and agricultural re-

sources, and caused for a time a stagnation in scientific and technological activities. The influx of many millions of refugees, while providing a potential supply of manpower, some of it highly qualified, at first created a formidable social problem. Until quite recently, therefore, Western Germany was engaged on a tremendous task of basic reconstruction, with a strong accent on 'first things first'. The efforts have been entirely successful: the refugees have been absorbed, industry and part of agriculture have been re-equipped, and the reconstructed and expanded research and development facilities are beginning to bear fruit. It should be remembered that the government favours freedom of economic enterprise.

The fluidity of industry and mobility of labour started during the war and the post-war years have largely contributed to a decentralization of German industry. During the past ten years new industries and enterprises have been set up in previously non-industrial areas, so that industry is now more widely spread over the country.

Research is deemed to be part of education, and therefore falls within the competence of the individual *Länder*. A planned co-ordination of scientific progress and economic planning would thus appear impossible at first sight. In reality, co-ordination is taking place through a series of somewhat complicated arrangements, and applied research is guided to some extent by a so-called *Schwerpunktsprogram*—a programme of priority targets. The pinpointing and evaluation of these targets is in itself an interesting subject for techno-economic study.

A major economic and social problem is now arising as a direct result of scientific progress, and affects both industry and agriculture. Industry is continuing to expand rapidly as a result of the adoption of new scientific methods, but a state of full employment has now been reached. In agriculture, on the other hand, the traditional system of small peasant proprietors is found uneconomic and incapable of taking advantage of the results of agricultural research. If these results were fully applied, German agriculture could reach an efficiency comparable to that of Britain in the next five or ten years; this would mean that some three million people could be transferred to industry, which needs them and could offer them a much higher standard of living. To achieve this result, the majority of small farmers would have to be regrouped into larger and more rational units, and equipped on modern technological lines at a reasonable cost. Economic trends have already set this evolution in motion and the Federal Government is now considering how to ensure that this major social change does not proceed haphazard, but in an orderly, efficient and rapid way without too much political and social dislocation.

United Kingdom

Everything that has been said in the previous chapter about countries with a high standard of living and a comparatively static population applies *par excellence* to the United Kingdom. In relation to its needs, Britain is not too rich in natural resources, and must rely to a large extent on overseas trade to ensure her well-being. Her traditional industries no longer enjoy the advantages of cheap as well as efficient labour and cheap sources of power. Expansion of nuclear power, which is a characteristic feature of British technological development, is clearly necessary but it does not nearly cover all requirements. As power supplies are increasingly costly and difficult to obtain, the usual method of raising productivity by giving each worker more horsepower may not be available. All scientific and technological efforts must therefore be directed towards improving the supplies of fuels and increasing the efficiency of their utilization. Some major technological advances are also necessary to maintain the industry on a competitive basis. Here, the prospective manpower shortage, coupled with the need to expand certain industries and services, clearly imposes as research criteria the necessity of telescoping and eliminating processes which require large numbers of operatives. Such a change, however, is bound to meet with strong resistance in an old-established industrial society, particularly in traditional industries with large capital investments as well as old-rooted management and labour skills and routine.

As for agriculture, it is already very efficient, but supplies only about 60 per cent of the country's requirements in spite of considerable subsidies. As the world demand for food is rapidly growing, not much reliance can be placed in the long run on reasonably cheap supplies from overseas. On the other hand, any further increase in British food production by conventional methods is likely to be uneconomic and tend to waste capital, e.g., by exhausting the soil. Consequently, there is an urgent need for biological research with a view to increasing the home supplies of high-grade foodstuffs by entirely new technological methods. Such research may well take 10 years or more before materializing in the form of practical results.

Holland and Norway

Both countries have small populations, though the density of population is much higher in Holland than in Norway. As total resources are limited, a selection of priorities becomes imperative, leading to a planned approach.

Holland, with very few natural resources and an expanding population, depends to a very large extent on foreign trade, and economic and social planning is mainly based on this central fact, capital investment being allocated according to priorities. These indicate the fields of applied research on which

efforts must be concentrated: intensive specialized agriculture and processing of high-grade foodstuffs, and the maximum integration of the limited resources of coal, oil and natural gas which are available. The high standard of education and a long tradition of technical skill and experience means that highly qualified technologists and technicians can be produced for service overseas as well as for developing modern methods of production at home, so as to make the best possible use of manpower and resources available.

In Norway, geographical conditions, while imposing limitations, also provide incentives for concentration on main issues. Fish, timber, specialized metallurgy and civil engineering provide the main fields for scientific and technological activity. Fish provides a living for a relatively large proportion of the population. Specialized metallurgy is linked with electro-chemistry, which in turn stems from the availability of large resources of hydro-electric power. The main aim of applied research and development in all these fields (including marine biology and biochemistry) is the development of new civil engineering techniques, a combination of thermal and electric process cycles, and above all the need to develop high-grade products and evolve 'know-how' for export, as the home market is too small for the potentialities of the country.

The Underdeveloped Countries

Most of the underdeveloped countries have large and rapidly expanding populations and a low standard of living; many of them possess largely untapped, sometimes very rich, natural resources. The population factor is dominant because of the food problem it raises. The first need, therefore, is to concentrate on improving the methods of producing, storing and distributing foodstuffs in order to raise the very low nutritional standards. Lack of capital equipment and of technological skills means that any new method must be relatively easy to instal and simple to operate, so as to make the best possible use of local initiative and skill. Applied research and development must proceed with emphasis on economic and social aspects rather than on scientific novelty. As labour is plentiful, capital-saving rather than labour-saving innovations must be given priority.

The investment of capital from outside as a moral contribution of the have's to the development of the have-not's is raising complicated and delicate political and economic problems. There is no lack of willingness to provide the capital and skilled manpower for the development of the underprivileged areas, though the former is much more abundant than the latter. It should be borne in mind, however, that such capital and manpower are being diverted from other employment much nearer home. Those who offer it are therefore entitled to an assurance that their efforts will not be wasted, and it is in this connexion that the main difficulties arise. Carefully thought out development

schemes, which fit in with practical necessities, are only too often frustrated or abandoned because of a refusal on the part of the recipient to have 'any strings attached', i.e., to earmark the capital for a particular project and to see that it is so applied. This is a problem which the various international bodies set up for the application of science and technology to the needs of the underdeveloped countries have not yet succeeded in solving, and one which requires an urgent and thoroughly objective study.

Italy

Italy presents what is probably a unique case—that of a country which is both highly developed and underdeveloped. Because of geographical and climatic features, the distribution of natural resources, and a wide range of economic and social conditions, almost every problem met with in both types of areas is present here. As quite a number of these problems are being successfully tackled, by a combination of government sponsorship and private or co-operative enterprise, the country might almost be regarded as a testing ground for applying the latest scientific and technological results, experience and techniques to underdeveloped areas. The north of Italy is very fertile, with ample resources in water power, natural gas, volcanic steam, etc., a well-developed industry and a vigorous population with a long tradition of skill and hard work. By contrast, the south is extremely poor, with few known natural resources, a soil largely eroded and a poor agriculture which is incapable of maintaining the large population on even a low subsistence level. Moreover, centuries of social insecurity have imposed on the population a pattern and an outlook on life which are particularly difficult to change and to adapt to modern conditions.

Taking Italy as a whole, it can be said that geography and climate have throughout the ages favoured a wide variety of agriculture, the development of water resources, and the building of communications, as well as the growth of skill and craftsmanship. As for agriculture, provided water supplies can be made available at the right time, virtually any crop can be grown by choosing the right soil, elevation, etc., at seasons which economically appear most convenient. But a great deal of basic rehabilitation must take place in the south before these favourable conditions can be fully exploited.

From the demographic point of view, the prospects for such a development are propitious. The population is large and growing, and as there has always been a tradition of migration, the shifting of labour is not a problem as in some other countries. This surplus and mobility of manpower should facilitate the development of backward areas without creating any social dislocations or a shortage of labour—provided that modern labour-saving techniques are applied at the right points at the right time.

The authorities recognize that the rehabilitation of the south is basically

a social problem, with food and health as first objectives. As with all problems of soil rehabilitation and agricultural modernization, the process must be slow, particularly in view of the historical factors mentioned above; much capital will have to be invested over many years according to a plan of priorities. The government are sponsoring the projects and providing a series of economic incentives to the highly developed enterprises from the north as well as to local firms. The development of agriculture has first priority, and research in genetics is being pursued with a view to developing plant varieties suitable for particular areas and soils so as to derive the maximum economic benefit from artificial irrigation at different seasons of the year. The same kind of research is being carried out in the field of animal breeding with a view to obtaining strains which, while suited to local conditions, are at the same time better producers of the main foodstuffs. It is interesting to note that this research in genetics is to some extent co-ordinated on an international scale with work on the best plant strains for underdeveloped areas which is now being carried out in various parts of the world, certain regions in Italy with similar conditions being selected as test fields.

A great deal of scientific and technological effort is being put into the development of the south, but one would have liked to have seen a more thorough study of the co-ordination between the problems which call for a solution and the applied research needed to solve them. It is to be hoped that the Italian experience will provide an example for other underdeveloped areas as well as a supply of skilled personnel for undertaking such work elsewhere.

ECONOMIC CRITERIA AND SOCIAL FACTORS

What then are the economic criteria by which the results of research can be judged?

Clearly, the value of search for fundamental knowledge cannot be assessed with any precision on a purely economic basis, because its specific usefulness is unknown and unknowable. What is known is that, without a flourishing and ever-expanding search for fundamental knowledge, successful investigations of an applied nature would dwindle in number and quality.

As for applied research, its objects fall broadly under two main headings: prevention of loss or making of savings under given conditions; and the creation of new conditions, processes or products. There is also a third category of cases—that in which the solution of a technological problem is of vital importance to the whole economic structure. The value of such a research target is negative, in the sense that, if no satisfactory answer is found to the problem, the assets of the whole economic system must be written down. If, for example, the economy of a country is overwhelmingly

dependent on available resources of coal, and if, for one reason or another, conventional methods of mining become impracticable, then the underground gasification of coal resources must be developed in a reasonably short time at whatever cost—unless adequate supplies of alternative fuels are readily available and can be relied upon. Fortunately, such cases of the 'categorical imperative' are rare and need not concern us here.

The first of the other two categories—preventing losses or effecting savings—lends itself to a more or less precise evaluation when the extent of the losses or of waste can be ascertained. For instance, the elimination of a killing disease in cattle or crops, which causes a known loss in production each year, has an economic value which can easily be assessed. What is much more difficult to estimate is the value of gradual, long-term improvements in conditions. For example, many widespread and relatively mild diseases of cattle or crops lower productive efficiency directly and indirectly in a proportion which may vary considerably, and it would be impossible to assess with any degree of approximation the economic value of applied research resulting in a gradual elimination of such diseases.

The second category—new conditions, processes or products—is much more amenable to assessment. Successful new results fall into two categories: those bearing directly upon the objectives of the investigation involved, and those which may have an indirect bearing in this or some other field. The value of direct results can be assessed by a form of market survey, and it is a sound principle to rely exclusively on direct results for assessing the economic value of the outcome of a research. However, the indirect results may in the long run be more important than the direct ones, particularly where entirely new discoveries are concerned. Another aspect must also be borne in mind, namely that a major direct result may not lead to practical applications until a second result from some other field becomes available; thus the invention of the gas turbine, for instance, would have had much more limited practical results if the discovery and development of certain types of special steel had not taken place quite independently at about the same time.

A good practical yardstick for economic evaluation is the so-called 'payout time', i.e., the time required—on the basis of the market assessment—for the amortization out of the earnings surplus of the total capital investment in research, development, and cost of the industrial installation. In view of the time-lag between the conception of a new idea and its full-scale implementation, the calculation of the 'payout time' must take into account the likely levels of costs, prices and demand at the time when the new technological process will be in full exploitation.

The 'payout time' technique is also useful for those who come second into the field. When research and development have resulted in a novelty which is reaching full-scale exploitation, a potential rival who has been doing research in the same field but is far less advanced will assess the extra cost

to himself of further independent work and the penalty of delay and unnecessary duplication. He may find that it is cheaper to strike a bargain with his more advanced rival, and thus come into the field earlier. 'Buying time' is an important economic factor, because delay may be very costly.

However, the 'payout time' technique is not always as simple to apply as it appears, particularly when the pace of technological progress is very rapid. It is clear, for example, that a radical technological innovation may render obsolete fixed capital, a substantial part of which may consist itself of modern equipment. With the best will in the world, no industry is likely to wish to 'scrap and replace' as often as possible, and this incidentally is a quite legitimate reason why certain inventions are not infrequently exploited only after some delay. An extreme case would be that of a rapidly developing new industry in which a major technological innovation had been put into operation at great cost; but before this cost could be written off from earnings surplus, yet another major innovation had occurred, again requiring a great deal of expenditure for full development. Clearly, this new expenditure can be fairly assessed only by adding to it the unwritten-off cost of the previous innovation. The precise way to treat fixed capital made suddenly obsolete by technological innovation is a controversial issue among accountancy experts.

Another item which can be costly in any process of technological innovation is manpower; all such aspects as redundancy, recruitment of suitable categories of labour, retraining, etc., have financial consequences, and should therefore be comprised in the economic assessment of the total cost of the innovation. They should also be considered as one of the consequences of the research results which led to the innovation. But the problem of manpower belongs to the social rather than economic context.

The central and dominant social issue in all fields of technological progress is the fear of redundancy. However irrational the basis for this fear may be in most cases, it is a psychological reality which cannot be brushed aside. Recently, the emphasis on automation has greatly intensified this fear, although, as has often been pointed out, automation is not something new but merely a continuation of technological progress at an accelerated pace which has been given a new—and misleading—name. It has however served the purpose of focusing attention on psychological as well as social aspects of accelerated technological change.

All past experience has shown that technological progress ultimately results in an expansion of employment, though it involves dislocation and changes, such as transfer, training, regrading, changes in recruitment, pensioning, etc. Modern automatic and semi-automatic techniques, for instance, are introducing new forms of stresses on the individual and even on the team; this may result not only in the elimination of certain age groups, but in the introduction of shorter working days or spells of duty in certain occupations;

this, in turn, would raise a number of social problems. Even with perfect planning and execution, there will always be a margin of individual hardship —people who are too old or unsuitable for adapting themselves to the new conditions. These cases must not be dismissed as the inevitable accidents of technological progress. The insurance principle should apply here; because such cases are comparatively few and scattered, they should be taken care of, all the more so as one of the consequences of technological progress is an increase in the volume of goods and services available to the community. If this increase constitutes the credit side, the cost of alleviating individual hardship as well as that of training, regrading, transfer, etc., must be reckoned on the debit side of technological innovation.

If this principle is accepted, there are ample means not only of exorcizing the ghost of redundancy, but also of presenting in a concrete form the growing attractions of a technological age. Not the least of these attractions will be the increase in leisure. This again is nothing new but a continuation of past trends brought about by technological evolution. The problem assumes however a new aspect because of increased shift working and the need for shorter spells of work in certain occupations owing to the stresses mentioned above. The spreading of leisure over the 24 hours of the day and the seven days of the week must needs affect the social pattern of life in industrial communities, particularly in areas of mixed industries. So far, greater leisure has resulted in an increased demand for services rather than goods, and there is no reason to think that this trend will not continue.

However, the need for greater fluidity of manpower both as between different types of occupation and within a given occupation must be accepted. This is perhaps the most formidable obstacle to the introduction of major technological innovations, particularly in old-established industrial communities with a stable social structure.

CONCLUSIONS

The present age presents something of a paradox: the various branches of science and technology are becoming more and more specialized, whereas the practical problems they raise demand for their solution the effective combination of several widely differing branches of knowledge. The co-operation of various types of mind and training is thus needed. But this co-operation can only be fruitful if the respective specialists have some knowledge outside their special field—if scientists and technologists are not ignorant of economic, social and management problems, while managers have some understanding of scientific and technological problems. This, of course, raises the whole question of education in a modern technological society.

The adequacy of the present educational systems is now the subject of

wide discussions and controversies throughout the world. A large number of ideas have been put forward: more general education in the schools and a longer time at the universities for specialized studies, courses in general subjects for science students at the universities, and courses in science for non-science students, refresher courses at the universities for executives after a certain period in industry, special schools of management and administration, and so on. It is the writer's view that much could be done by starting to stimulate thinking on the social implications of science and technology in secondary schools. Senior boys and girls should be taught by means of well-chosen examples about the paramount importance of science in a modern society, and stimulated to seek out the relevant information and to think about it. One can then hope that later, in their active life, they will have acquired the desire and the ability to find out the connexions between the various strands and forces that make up the society in which they live.

BOOKS AND PUBLICATIONS

The Reluctant Patrons

A. Hunter Dupree, *Science in the Federal Government,* A History of Policies and Activities to 1940. Cambridge, Massachusetts, The Belknap Press of Harvard University Press, 1957, 460 pp., $7.50.

Dr. Johnson's *Dictionary of the English Language* contains the following definition of a patron: 'Commonly a wretch who supports with insolence, and is paid with flattery.' In assuming their pre-eminence as financial sponsors of learning, modern governments have found, like Lord Chesterfield, that a patron's lot is often invidious. On the other hand, the recipients of their bounty have experienced the perils which may attend over-hasty acceptance of even the most disinterested generosity of Leviathan.

The British Government has been constrained to shield its supported institutions from the 'insolence' of Treasury control by interposing the University Grants Committee and thus, though the amount of grants may be found insufficient, their acceptance is not felt to involve an undue sacrifice of independence. In the United States, the flood of government funds made available since the war for research and experiment has not always been unreservedly welcomed, and misgivings have been expressed regarding the consequences of too vigorous official intervention either in the detailed conduct of research or in the affairs of the individuals who conduct it. In the words of a Committee of the American Association for the Advancement of Science: 'Although government support has been a major source of recent scientific growth, it has been accompanied by influences which are in some respects inimical to basic needs of science.'[1] Walter Elliot comments more forcibly: '. . . the State prods and pokes and investigates the scientists till the whole structure seems at times in danger of cracking.'[2]

These problems arise essentially within a context in which the State has accepted the obligation of large-scale support for scientific investigation, and claims a concomitant share in its control. Those who stress the dangers of this claim do not in general deny the need for government financing, and the predominant position of the State as patron tends to be taken for granted.

In contemplating the magnitude of United States federal appropriations for research ($2,500 million in 1957) it is all too easy to forget how recently this pattern has been established. In the early days of the Republic, and

1. See *Impact,* Vol. VIII, No. 1, March 1957, pp. 52-61.
2. *Bulletin of the Atomic Scientists,* November 1956.

indeed well into the nineteenth century, support for learning was considered not merely non-obligatory, but outside the powers of the federal government and not permissible under the Constitution.

Mr. Dupree's study illuminates the foundations of this viewpoint and shows how pervading it was on the early activities of the United States Government. He traces the process of its gradual erosion to the point at which, without constitutional amendment, that Government could begin to assume a dominating position as the patron of American science.

Three main points emerge from his narrative. First, the issue of federal support of learning was linked from the beginning with wider disputes regarding the extent of Congressional powers. Secondly, the early temper both in Congress and the country was often hostile enough to block the endeavours of the most enlightened individual friends of science, even including the President. Thirdly, only by piecemeal and indirect devices could resistance be broken down and establishments be contrived; emphasis had consequently to be placed not on basic research and enduring institutions, but on short-term projects and immediate needs.

Science in the Federal Government is a long book, dense with detail. Inspired by the National Science Foundation and sponsored by the American Academy of Arts and Sciences, it has many of the marks of the institutional study—flatness of style, monochromatic presentation, and a determined insistence on exhaustive completeness. The author observes that the availability of a body of literature on recent events 'played a part in the selection of 1940 as the terminal date for the present study'. And perhaps, after 440 pages, flesh and blood could no more. A final bibliographical note seems almost to complain:

> In a perfectly ordered world the author of a synthesis such as this one would eschew primary sources entirely. Monographs of uniform quality stacked neatly along the path of his story would serve him well enough. Unfortunately . . . no such simple situation exists in this field.

In fact, the traces of access to primary sources (mostly biographical, but also including periodicals and government documents) are welcome because they herald passages that are especially readable for more than the novelty of their material. Mr. Dupree is a historian, and the effect he achieves by many sure touches of detail is more substantial than that of his occasional flights into 'synthesis'. To the student of government his book presents a fascinating case study, in which the basic aspects of a period are competently set out, undistorted by the presence of any very particular point of view.

The imperfection and ambiguity of provision for scientific objectives in the United States Constitution did not arise from inattention on the part of its framers. Many members of the Constitutional Convention had the cause of learning at heart: and clauses were drafted to give Congress power 'to

establish seminaries for the promotion of literature and the arts and sciences', 'to grant charters of incorporation', and 'to establish public institutions, rewards and immunities for the promotion of agriculture, commerce, trades and manufactures'. But none of these provisions reached the final text. Their discussion became entangled in the general wrangling over limitation of federal powers: classed with roads, canals and banks as 'internal improvements', they fell victim to the suspicion of the smaller States and of the opponents of strong central authority.

After Franklin's motion on canals had been rejected,

Madison and Pinckney moved to empower Congress to 'establish a university'. Gouverneur Morris tried to smooth this over by saying 'it is not necessary. The exclusive power at the Seat of Government will reach the object'. This statement Madison carefully recorded for future use. Pinckney's influence probably brought over North and South Carolina to join Pennsylvania and Virginia, but Connecticut split, leaving the vote six against, four in favour, and one tied.

As a result, the word 'science' appears in the Constitution only in the patents clause—Congress is given power not to 'promote the progress of Science and useful Arts' in general, but only to do so 'by securing for limited times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries'.

The proceedings of the Convention thus left the infant Federal Government without an explicit mandate for the promotion of scientific endeavour. Roger Sherman of Connecticut, a member of the Convention, was able to claim that, since the national university had been rejected, Congress had no power to create scientific institutions. Thereafter, it was easy for Congressional obscurantists to don the glittering armour of constitutional defence.

One John Churchman, 'an ingenious surveyor from the Eastern Shore of Maryland', applied to the First Congress for assistance towards 'a voyage to Baffin's Bay for the purpose of making magnetical experiments'. Even the proposal's main supporter in the House, John Page of Virginia, conceded that 'authority and ability' in such matters might inhere rather in the State legislatures.

No congressional debate took place: despite a favourable committee report, all enthusiasm evaporated when the point of making an appropriation was reached. In 1796,

when one Frederick Guyer made his try to get some help for his lunar observations, the committee of the House of Representatives reported not only that his improvements were without merit, but that 'it is their opinion that application to Congress for pecuniary encouragement of important discoveries, or of useful arts, cannot be complied with, as the Constitution . . . appears to have limited the powers of Congress to granting patents only'. One member, who was not prepared to fight for the hapless Guyer's lunars, said he was 'sorry to have established as a principle, that this Government cannot Constitutionally extend its fostering aid to the useful arts and discoveries', but

he did not press for a discussion. Such an exchange does not make constitutional law in the grand manner. But the tide ran clear and strong against the establishment of any power of the government to subsidize science directly.

Even so distinguished an alliance as that of Washington, Madison and Jefferson was powerless to advance the cause of a national university. Congress could not be persuaded even to accept the 19 acres of land and 50 shares of canal company stock which Washington was prepared to donate for the purpose. Though no federal funds were required, a proposal to postpone the resolution authorizing acceptance was adopted by 37 votes to 36.

When Charles William Peale sought support for a 'Museum in the City of Washington', Jefferson let his constitutional principles outweigh his scientific proclivities, replying that 'nothing could be done without an amendment'. In 1807 he talked over with Joel Barlow the draft of a bill to establish a 'national Academy and University' on European lines, including proposals for a chancellor with broad powers, travelling professors, printing presses, laboratories, libraries, scientific apparatus, and botanical gardens. Barlow suggested that such a university as he proposed could take over the functions of a military and naval academy, the patent office, the mint, and 'a geographical and mineralogical archive of the nation'. But all these schemes collapsed, and Jefferson complained

that Congress was balky about amending the Constitution and that 'people generally have more feeling for canals and roads than education', only casually mentioning an even more immediate deterrent when he said that 'the chance of war is an unfortunate check'.

That the threat of war should help to block what was in fact a far-reaching proposal for the centralization of scientific effort was paradoxical; for it was precisely from the needs of later wars that pressure for such centralization was to arise, as was shown by the establishment by Roosevelt of the Office of Scientific Research and Development in response to the need for war preparations in 1941.

However, Jefferson had at least realized the possibility of using military votes for scientific ends. The celebrated Lewis and Clark expedition was supported by a token grant under the commerce clause—but 'the entire pay of the company, and all their rations while on U.S. soil, came from the War Department'. In seeking permission from Spain for the exploration of the Missouri River, Jefferson claimed 'no other view than the advancement of geography'. But he would 'give it the denomination of mercantile, inasmuch as only in this way would Congress have the power of voting the necessary funds; it not being possible to appropriate funds for a society, or a purely literary expedition, since there does not exist in the Constitution any clause which would give it the authority for this effect'.

Commercial and military utility was likewise the justification, in 1807, for the first major scientific appropriation made by Congress: $50,000 for a Coast Survey under Ferdinand Rudolph Hassler, formerly topographer to the canton of Berne. This sum proved hardly sufficient even for the purchase of instruments; and official sympathy was scanty, despite the friendly attitude of Madison as president. Hassler overcame the hazards both of war and of government frigidity, and finally got into the field in 1816, only to receive in February 1817, with work preliminary to setting up a base line still in progress, a letter from the Treasury Department asking when he would finish.

The question served notice that most people in the government expected quick, tangible results and immediate relief from the necessity of spending money on the business. . . . Disdaining to keep in touch with a grumbling Congress, Hassler was still going ahead on a scientific survey which would outdo the best in Europe, when in the spring of 1818 he suddenly found that an act had been passed providing that only military or naval officers could be employed on the Survey.

The chaplain of the Navy had been 'busy telling Congress that he could do a better survey in less time'. Hassler was forced out—to no advantage. Money continued to be spent, but 'with no comprehensive plan and no continuity of personnel, the results were immediately recognized as worthless'.

Thus for the period up to 1830 the government failed to demonstrate that it had the administrative resourcefulness and understanding to conduct a long-range scientific program. It also failed to recognize, granting that the Coast Survey had an immediate and practical objective, that fundamental science is sometimes a safer and cheaper road to usefulness than are hard-headed economy and direct methods.

Madison asked again for a national university in his last message to Congress. Nothing was done, though in 1818 land was granted for a botanical garden, which seems to have failed to bloom.

A more significant failure was that of John Quincy Adams, who made the government's duty towards knowledge the theme of his first message to Congress in 1825: 'Moral, political and intellectual improvement are duties assigned by the Author of our Existence to social no less than individual man.'

He departed from Jefferson's position, holding not merely that scientific enterprise was desirable and worthy of an amendment, but that its support was both constitutional and obligatory. Further, he was tactless enough to point out that Europe, though without the blessings of democratic liberty, was nevertheless advancing science at a far greater rate than was America. 'In recommending an observatory he taunted his countrymen with Europe's more than one hundred and thirty "lighthouses of the skies" against none for the United States.' (He was to be taunted in turn with this phrase through the following decade—usually with the 'of' misquoted as 'in'.)

Adams' enlightened proposals included a university, an observatory, an efficient patent office, and a new executive department to plan and supervise internal improvements generally and science especially. Yet they evoked 'shock and horror' even among his own Cabinet. They met with ridicule in the country, and had no chance of adoption by Congress. Nor did any favourable movement of opinion occur during his term: 'It would have been difficult in 1829 to propose a more unpopular measure than the national observatory or a national observatory.'

Popular indifference, not lack of men of vision, must be blamed for the virtual absence of scientific patronage during the first 40 years of the United States. Constitutional obstacles were important, not crucial; they could have been overcome if only the inspirations of presidents had met with a more sympathetic echo among the members of the legislative branch.

It was an Englishman who at last shamed Congress into action, if not into expenditure. James Smithson, a British chemist, left property worth half a million dollars 'to the United States of America, to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase and diffusion of knowledge among men'. Though 'States' rights' senators opposed acceptance of the legacy on the usual grounds, they could muster only 7 votes against 31. But a motion that 'the Smithsonian Institution be a scientific and literary institution', in fact a university, was defeated by 20 to 15. The Institution became partly a museum, partly a source of research funds: the first foundation under the Federal Government to play a significant part in the advancement of theoretical knowledge, it dates effectively from 1846; Smithson died in 1829.

The 1830's in fact mark the transition from the epoch of American science as a gentlemanly occupation for the amateurs of philosophical societies to the era of technical innovations and the beginnings of serious government activity in research. Where young specialists had been able to look only to the few colleges, then to the developing services of the State governments, they now began to find opportunities also in industry and the central administration. The patents office was equipped with administrative machinery in 1836—in the early days, the secretary of state and the attorney-general had constituted a board to consider and approve inventions, and had done their best in spite of difficulties. But:

> there is something sublime and pathetic in the spectacle of the secretary of state and a battery of professors from the University of Pennsylvania gathered around a distilling apparatus in the secretary's office to test the efficiency of a mixture supposed to help make salt water fresh.

A short-lived precedent for the direct subsidy of invention was set in 1842, when Samuel Morse received $30,000 for the construction of an experimental telegraph line; $20,000 was granted for development of an electric

locomotive in 1849, but Congress refused to vote further funds and the precedent lapsed.

The disastrous exclusion of civilians from the Coast Survey ended in 1832, and Hassler was reinstated—by 1840 the survey was receiving $100,000 a year. But the hostile element in Congress had inserted a provision that 'nothing in the act, or the act hereby revived, shall be construed to authorize the construction or maintenance of a permanent astronomical observatory'. In fact, a Naval Observatory was established by stealth in 1842, using $25,000 voted for a 'Depot of Charts and Instruments'. Adams was 'delighted that an astronomical observatory—not perhaps so great as it should have been—had been smuggled into the number of institutions of the country'.

The Wilkes expedition of 1838-42 could claim a character 'altogether scientific and useful', though its composition was largely naval. Its results came from Latin America, the Antarctic, the Central Pacific Islands, and the western coast of America.

> It touched the sciences of ethnology, anthropology, zoology in all its major branches, geology, meteorology, botany, hydrography and physics. In addition, the surveys resulted in large numbers of charts, some of which were not the worst used by the Navy at Tarawa in 1953. . . . The total cost ran to $928,183.62, some three times the specific original appropriation.

The confusions arising from attempts by Congress to administer directly the publication of the Wilkes expedition reports helped to mould opinion in favour of permanent research institutions. But the old hostility died hard: in 1858 the vote for printing the report of the Smithsonian was only 84 to 50, and

> Some congressmen never tired of remarks such as Simon Cameron's 'What do we care about stuffed snakes, alligators and all such things?' On another occasion he lamented, 'I am tired of all this thing called science here.'

Commander Perry endeavoured to exclude all civilian scientists from his expedition to Japan; nevertheless a few botanists managed to go along.

By 1854 the Coast Survey appropriation had reached $489,000—yet the Survey was still, in theory at least, an *ad hoc* enterprise which was only kept in being because its work was unfinished. 'If the day ever came when Congress considered that the coasts had been adequately mapped, the Survey's reason for existence would vanish.' Broad long-term planning was impossible, and fundamental research was almost entirely excluded from its scope. Yet 'before the Civil War the Coast Survey was the best example of the Government in science'. When the Naval Observatory was allowed its name in 1844, and Matthew Maury became its head, he attained international celebrity not by astronomy but by meteorology, drawing up *Wind and Current Charts* of the oceans. Henry L. Ellsworth, as commissioner of patents,

seized the opportunity to sponsor substantial ventures in agriculture, involving both the collection of farm statistics and the investigation of soil chemistry. Special appropriations for such purposes gradually rose (varying between $30,000 and $70,000 in 1856-62), but no separate establishment was devoted to agriculture.

A bill for the establishment of colleges endowed by grants of land was introduced into Congress in 1857. The tables now were turned—it passed both Houses, but was vetoed by President James Buchanan on grounds of constitutional scruple.

At the outbreak of the Civil War, patterns of *de facto* federal expenditure on science had become established, but only for limited and very specific purposes. The power to create permanent institutions had not been admitted *de jure*. Jefferson Davis of Mississipi led the opposition to the land-grant colleges in the Senate, not because of any opposition to science (he was a 'staunch friend of the Smithsonian'), but because he felt that their creation violated the rights of the States. 'The accomplishments of the pre-war years —Smithsonian, Coast Survey, Naval Observatory, and agricultural research in the Patent Office—had evaded the constitutional issue.' In 1862 Congress took an unambiguous step forward by establishing the Department of Agriculture, charged to 'acquire and diffuse . . . useful information on subjects connected with agriculture in the most general and comprehensive sense of the word', with a commissioner empowered to conduct 'practical and scientific experiments'. In the same year a land-grant college bill was passed: 'From this time on, Congress proved itself at least occasionally willing to establish permanent bureaus with ample grants of power explicitly stated in organic acts.'

The broad issue was settled, and 'the era of bureau-building had begun'. It is perhaps unnecessary to follow Dupree's detailed account of how subsequent administrative machinery developed. Department spawned Bureau, Bureau Division. All the complex tangles whose study is the delight of today's students of political science began to take shape.

The centre of interest of the typical bureau was not a scientific discipline, but a problem. (The idea of a department of science was mooted in the eighteen-eighties, but died.)

Instead of a chemist who tested both fruits and fertilizers, the problems of growing particular crops or improving animals became central, and the bureau mobilized teams of experts from various disciplines to attack each one. Such an approach required on the one hand stability to concentrate on a given line of investigation over a period of years, and on the other hand the flexibility to shift resources as the problem changed.

Flexibility was also required in countering the vagaries of Congress; often, important organisms could only be brought into being by the insertion of surreptitious riders in appropriation bills, and continuity over many years

was threatened by the risk that a clause in estimates might be casually deleted and abolish a whole division.

The problems of scientific activity in war form another field of immense scope, well handled by Dupree. In 1862 a curious amateurism still ruled—Dahlgren as Chief of the Bureau of Ordnance

> recounts being called to the White House, where Lincoln had received a sample of gunpowder. The President went to the fire, 'clapped the coal to the powder and away it went, he remarking "there is too much left there" '.

The Manhattan Project was still a long way off.

In the intervening years, experience of the necessities of short-term planning, and the consequent difficulty of engaging in fundamental research, left marks on the structure which developed. By 1939, to quote James Phinney Baxter, 'the services had not learned yet, as American industry had, that it is fatal to place a research organization under the production department'.[1]

They learned better, and the success of the 'crash programme' stands as a monument. But Dr. Vannevar Bush, who as Director of the Office of Scientific Research and Development had controlled effectively the whole national research effort, afterwards found it necessary to re-emphasize to Congress (in testimony before the Select Committee on Post-War Military Policy) that:

> Research . . . is the explanation of the unknown. It is speculative, uncertain. It cannot be standardized. It succeeds, moreover, in virtually direct proportion to its freedom from performance controls, production pressures, and traditional approaches.

Mr. Dupree does not cite this passage: it is outside his period. But if a single lesson is to be distilled from his pages, Dr. Bush's words sum it up as well as any.

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1. *Scientists against Time*, Boston, Mass., 1956.